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… all conservation of wilderness is self-defeating, for to cherish we must see and fondle, and when enough have seen and fondled, there is no wilderness left to cherish.

Aldo Leopold, Wisconsin, Marshland Elegy

1 Introduction & Background

1.1 Vital Signs Monitoring within the National Park Service

The 1980 State of the Parks Report (National Park Service, 1980) focused on specific threats to park resources. These threats, visitor use, alien species, adjacent land development, etc., "have the potential to cause significant damage to park resources." To counter these threats, it was recommended that (1) comprehensive inventories of important natural resources should be completed within each park in the system; (2) accurate baseline data on park resources be obtained and; (3) that comprehensive monitoring programs be implemented to detect and measure changes in resources and ecosystems.

Responding to these and other resource management concerns a group of park service scientists and managers met in the mid 1980s to lay a foundation for science based management of national parks. This group, which came to be known as the "Evison Task Force" (National Park Service, 1987), articulated a policy for the inventory and monitoring of natural resources under National Park stewardship. In response to the recommendations of this group the Park Service committed to a program of exploring how it could implement inventory and monitoring in national parks (Davis, personal communication – Appendix I).

While the Park Service received funds to begin a prototype monitoring program in 1992, the most significant milestone in the development of the monitoring program was the passing of the National Parks Omnibus Management Act of 1998 requiring the National Park Service to Inventory and Monitor natural resources within parks. This legislation provided a minimum level of support for initiating natural resource monitoring that could be built upon in the future. To facilitate the implementation of long term ecological monitoring within the National Park System, 270 national parks with significant natural resources have been organized into 32 networks[1]. Networks of parks, linked by geography and shared natural resources, share funding and professional staff to plan, design, and implement an integrated monitoring program.

1.2 Purpose of Monitoring

Maintaining ecosystem integrity "or the capacity of an ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization" is the ultimate goal of many resource management programs in the Park Service and elsewhere (Noon, 2003). In meeting this goal natural resource managers in the National Park Service face increasingly complex and challenging issues and are asked to provide scientifically credible data to support their decisions and to defend their actions. Natural resource management today requires vigilance unknown in the early day of the Park Service. Threats to natural resources and ecosystems processes are growing daily. Understanding these threats or stressors, the condition of extant resources, the pathways of impacts from stressors, and the affects of stressors on natural resources within National Parks requires a commitment to research and monitoring of ecosystem structure and function on a scale unprecedented in our history. Many of the threats to park resources, as identified above, originate outside park boundaries. Information gleaned from integrated monitoring can provide resource managers with sound data to better understand the threat process, to determine the status and trends in status of resources, and to formulate management actions to protect park resources.

Integrated monitoring has been defined as "systematic, consistent, and simultaneous measurements of physical, chemical, biological, and human-effects variables through time and at specified locations." In

[1] http://science.nature.nps.gov/im/monitor/vsm.htm#Networks

theory, by monitoring a wide range of variables at long-term sites, it is possible to gain an understanding of how ecosystems function and respond to change (Bricker & Ruggiero, 1998). Coupling monitoring with research and modeling may make it possible to predict what will happen in the future and, if necessary, devise appropriate response strategies.

Monitoring includes the repeated measurement of indicators of ecosystem or resource condition. Noon (2003) defines ecosystem indicators as biotic or abiotic attributes of the ecosystem that can be measured or estimated and that provide quantitative information on the state of an ecological resource. Monitoring can be undertaken to establish whether the current status of an ecosystem attribute matches management expectations or lies within acceptable limits of variation for that particular attribute. Monitoring can reveal if management activities have produced the expected outcome. Monitoring can reveal if a particular stressor is affecting one or more ecosystem attributes, can help develop a predictive understating of why the condition of an attribute is changing, and can indicate when more aggressive management action is needed. A meaningful monitoring program should provide insights into cause and effect relationships between stressors and the attributes they affect.

Monitoring may also be done to determine if environmental laws have been implemented, and of specific relevance to the vital sign monitoring program, to determine if trends (temporal and/or spatial) in selected vital signs (ecosystem indicators, attributes, or elements) that characterize the state of an ecological system are leading towards or away from an acceptable level of ecosystem integrity (Noon, 2003). Monitoring can also provide early warning of changes in ecosystem attributes that foreshadow early stages of decline in condition.

Ecosystem monitoring can take several approaches. Davis *et al*. (1994), quoting others, suggests that establishing baseline levels for energy flux, biodiversity, nutrient or constituent budgets, and population dynamics can provide a mechanism for monitoring (over time or location) the condition of ecosystem attributes. Deciding upon the type of monitoring to be done can include may considerations and requires some concept of ecosystem structure and function. According to Regier (1993) conceptualizing ecosystems follows two general trajectories. The first is an holistic view which describes ecosystems in terms of species, communities, land forms, climate, etc. This view often presents the living components of an ecosystem as a distinct hierarchy of individuals, species, populations, and communities that are superimposed on and limited by the physical elements of the ecosystem. The second view which he calls the reductionistic analytical view describes ecosystems in terms of cascading energy, material cycling, or information organizing. Knowing the condition (condition monitoring) of natural resources or the state of ecosystem processes is crucial to protecting or managing natural resources. Stressor monitoring discounts the condition of ecosystem attributes focusing on measuring the level or intensity of an ecosystem stressor. Stressor monitoring presupposes that the effects of a given stressor on ecosystem attributes are known or hypothesized and that an attributes response to the level or intensity of a particular stressor is also known. An overall approach to monitoring should combine both condition and stressor monitoring to build a complete picture of selected ecosystem attributes or processes.

Monitoring within the national park service focuses of the concept of ecosystem vital signs. Vital signs are defined as:

> … a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

Vital signs monitoring within the National Park Service provides a composite strategy to monitoring planning that embraces several scales of monitoring activities. It leaves open to program planners the opportunity of determining the course, extent, and focus of monitoring activities taking into consideration the boundaries of ecological stewardship, ecological functionality and the unique concerns of park natural resource managers. Monitoring can focus at several scales: on the condition of unique resources within specific park units, or on overall ecosystem integrity within broad landscapes or clusters of park units (networks) that share common ecological qualities.

Managing public lands for conservation of resources is not only an ecological process, but more often as not a political one as well, with the ecological aspects of resource management often taking second place to politics (cf. Davis & Wyberg, 1998). For resource managers to play a meaningful role in the process of institutionalizing the collection of baseline ecological information that will justify one course of management action over another, it is essential to formulate long-term environmental management plans based upon scientifically sound data and models of ecosystem function (cf. Davis & Wyberg, 1998).

1.3 History of Resource Management Stewardship in the National Park Service

In August of 1999 Robert G. Stanton, Director of the Park Service announced a new program of resource stewardship called the Natural Resource Management Challenge which was intended to revitalize resource management in national parks (Stanton, 1999). That same month, the "Natural Resource Challenge: The National Park Service's Action Plan for Preserving Natural Resources" was published. This document, prepared by the National Leadership Council, listed all major elements of the Inventory and Monitoring (I&M) program as it is presently constituted. This document sets the stage for the I&M program stating that, "For most of the 20th century, we (the National Park Service) have practiced a curious combination of active management and passive acceptance of natural systems and processes, while becoming a superb visitor service agency," and that "Protection of … natural resources now requires active and informed management to a degree unimaginable" at the creation of the National Park Service in 1916 (NLC, 1999).

National parks have long been valued for their natural resources and recreation potential. In establishing Yellowstone National Park in 1872, Congress "dedicated and set apart (nearly 1,000,000 acres of land) as a … pleasuring ground for the benefit and enjoyment of the people" (16 U.S.C. 1 § 21). Following on the heels of Yellowstone, Congress took steps to preserve additional natural heritage sites and other natural places as public parks. It wasn't until forty-four years after the establishment of Yellowstone though, with the passage of the Organic Act of 1916 (16 U.S.C. 1 § 1), that the National Park Service came into being, establishing a pattern of care for protecting and managing the natural resources of our national parks.

> The service thus established shall promote and regulate the use of the Federal areas known as national parks … by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, *which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations* (italics added).

Science in National Parks has been encouraged and invited since the earliest days of the service. Wright *et al.* (1933) proposed "That no management measure or other biotic relationships shall be undertaken prior to a properly conducted investigation," and that "a complete faunal investigation, including … a thorough zoological survey and formulating a wild-life administrative plan, shall be done in each park at the earliest possible date." In 1945 the National Parks Association was advocating national parks as sanctuaries for the "scientific study and preservations of all animal and plant life originally within" their boundaries "to the end that all native species … be preserved as nearly as possible in their aboriginal state" and that "scientific administration be applied to all phases of park maintenance" (National Parks Association, 1945). In 1962 two select committees were created and charged to (1) review natural history research needs and opportunities in national parks and (2) review wildlife management in national parks

(Sellars, 1997, pp. 200-210). The first of these proposed a holistic evaluation of natural resources within national parks (The Robins Report; National Park Service, 1968), and recommended that national parks should be regarded as ecosystems where evolutionary processes are left to act naturally to preserve the unique features of each park. "Naturalness, the avoidance of artificiality, should be the rule." The second committee recommended a greatly expanded research program oriented towards management needs be developed, and that the "ecological scene" within parks should be preserved or recreated to that as viewed by the first European visitors to this land (Leopold *et al.*, 1963).

Two significant documents relative to the integration of science into park management activities were published in 1992. The first, known as the Vail Agenda (National Park Service, 1992), indicts the park service for not having sufficient information and resource management or research capability to pursue and defend its mission in Washington, D.C. Furthermore, this report states, "Natural resources in the park system should be managed under ecological principles that prevent their impairment," and " The National Park Service must engage in a sustained and integrated program of natural … resource management and research aimed at acquiring and using the information needed to manage and protect park resources." The second, Science and the National Parks (NAS, 1992), recommends a movement to a "new culture" in the national park system that guarantees a long-term commitment to funding, and intellectual and administrative integration of science in national parks (NAS, 1992). This report also suggests the need for an explicit legislative mandate for science in national parks, separate funding and autonomy for science activities, and the enhancement of scientific credibility within national parks. Finally, a strong "Parks for Science" program was recommended especially in parks that encompass undisturbed natural areas and wilderness (NAS, 1992).

1.4 Legal Mandates Addressing Natural Resource Stewardship

Since the establishment of the National Park Service, Congress has passed significant legislation intended to not only protect the natural resources within national parks and other federal lands, but also to address concerns over the environmental quality of life in the United States generally. Among these are:

- The Taylor Grazing Act of 1934
- The Air Quality Act of 1963 as amended in 1967, 1977, & 1990 (42 U.S.C. 85 [§ 7401 & § 7470])
- The Wilderness Act of 1964 (16 U.S.C. 23 [§ 1131])
- The National Environmental Policy Act of 1969 (NEPA) (42 USA 55 [§ 4321])
- The General Authorities Act of 1970 (16 U.S.C. 1a [§ 1]) reaffirming the declaration of the Organic Act.
- The Federal Water Pollution Control Act & Amendments of 1972 & 1977 (The Clean Water Act) (33 U.S.C. 26 [§ 1252])
- The Environmental Quality Improvement Act of 1970 (42 U.S.C. 56 [§ 4371])
- The Coastal Zone Management Act of 1972 (16 U.S.C. 33 [§ 1452])
- The Marine Protection, Research, and Sanctuaries Act of 1972 (16 U.S.C. 32 [§ 1431])
- The Endangered Species Act of 1973 (16 U.S.C. 35 [§ 1531]),
- The Forest and Rangeland Renewable Resources Planning Act of 1974 (16 U.S.C. 36 [§ 1642] This act has been cited as congressional authorization for the inventory and monitoring of natural resources on all federal lands.

Most significantly for the National Park Service, the National Parks Omnibus Management Act of 1998 (16 U.S.C. 79 [§ 5911, § 5931, & § 5934]) establishes the framework for fully integrating science into the management processes of the National Park System and charges the Secretary of the Interior to "continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System." Section 5939 states that the purpose of this legislation is to:

1. More effectively achieve the mission of the National Park Service;

2. Enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes;
3. Ensure appropriate documentation of resource conditions in the National Park System;
4. Encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value, and
5. Encourage the publication and dissemination of information derived from studies in the National Park System.

In § 5934, the Secretary of the Interior is charged with developing a program of “inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources.” A summary of federal legislation relative to the national parks, natural resource management, and environmental protection can be found at the National Park Services Inventory & Monitoring web page.[2]

1.5 National Park Service Monitoring Policy & Guidance

“Applying scientific information to park management decisions to preserve park resources” and “Promoting parks as centers for broad scientific and scholarly inquiry at all levels” is identified in the Park Service’s 2001-2005 Strategic Plan as one of its guiding principles (National Park Service, 2000a). The 2001 National Park Service Management Policies (National Park Service, 2000b) state that "Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions.” Furthermore, "The Service will:

- Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents.
- Define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under its stewardship, and identify the processes that influence those resources.
- Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals.
- Analyze the resulting information to detect or predict changes, including interrelationships with visitor carrying capacities, that may require management intervention, and to provide reference points for comparison with other environments and time frames.
- Use the resulting information to maintain – and, where necessary, restore – the integrity of natural systems (National Park Service, 2000b, p. 31)."

Specifics of the organization and expectations of the Inventory and Monitoring program have been detailed in several National Park Service guidance documents and Internet based resources. These include the Natural Resources Management Guidelines[3] (NPS 77) and the Standards and Guidelines for Natural Resources Inventory and Monitoring[4] (NPS 75). Major goals of the monitoring program identified in NPS 75 include:

1. Determining the nature and status of park resources,
2. Monitoring park ecosystems to better understand their dynamic nature and condition,
3. Providing reference points for comparisons with other, altered environments,
4. Integrating monitoring information into park planning, management, and decision making,
5. Establishing monitoring as a standard practice throughout the park service, and

[2] http://science.nature.nps.gov/im/monitor/LawsPolicy.htm
[3] http://www2.nature.nps.gov/nps77/
[4] http://science.nature.nps.gov/im/monitor/docs/nps75.pdf

6. Forming partnerships with other natural resource agencies in order to pursue common goals and objectives.

The purpose of the service-wide Inventory and Monitoring Program is to “Chart a course and provide leadership and information needed by the National Park Service to preserve and protect the natural resources placed under its trust by the American people into the 21st Century and beyond;” and “Through its accomplishments, the Program will further enhance the National Park Service's stature as an international leader in natural resources management and stewardship” (NPS 75).

1.6 Description of Mediterranean Coast Network & Network Parks

The Mediterranean Coast Network of National Parks includes Cabrillo National Monument in San Diego, Channel Islands National Park offshore of Ventura, and Santa Monica Mountains National Recreation Area straddling the Los Angeles and Ventura county line along the coast between Santa Monica and Oxnard, California. All three of these parks share characteristics of coastal and inland Mediterranean-type ecosystems which are characterized by hot dry summers, cool wet winters, evergreen sclerophyll shrub vegetation, and oak woodlands. All three parks are located within 320 kilometers of each other along or off-shore of the coast of the Southern California Bight (Figure 1.1).

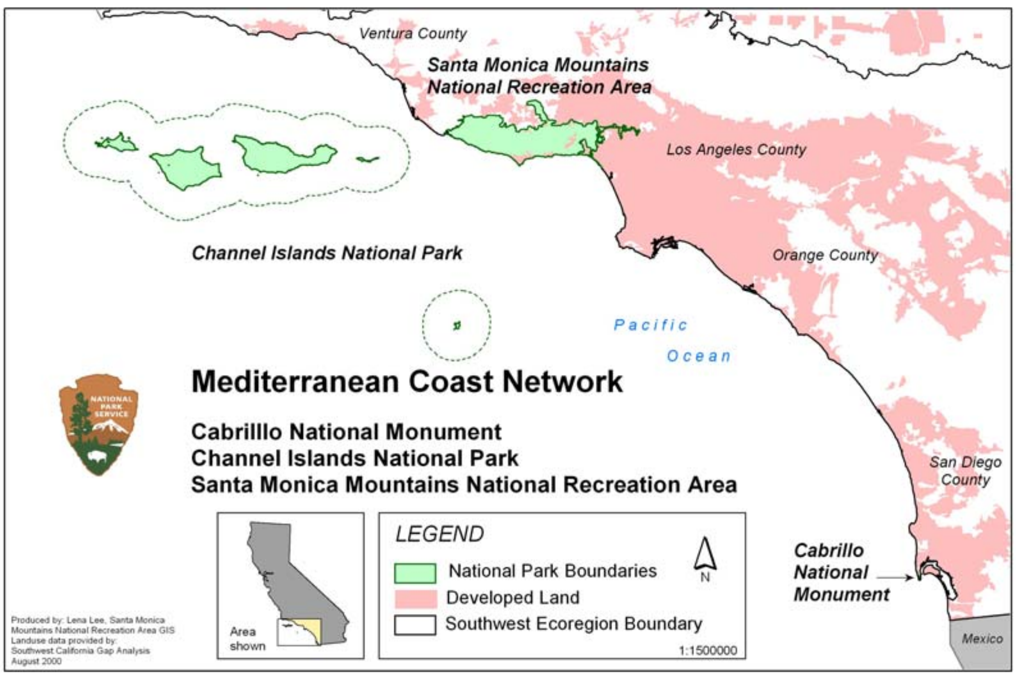

Figure 1.1 Mediterranean Coast Network of National Parks

The three parks of the Mediterranean Coast Network make a significant and unique contribution to the Southern California experience. As three islands of natural open space adjacent to or within one of the largest metropolitan regions in the United States these three parks provide refuges for wildlife and native vegetation, and opportunities for scientific research, natural history education, equestrian sports, mountain biking, hiking, picnicking, and camping. Opportunities for ocean fishing, scuba diving, snorkeling, ocean kayaking, and tidepool exploration, are also available. All of these possibilities are within just a few miles of the major urban centers of Southern California.

1.6.1 Mediterranean-type Ecosystems

All parks of the Mediterranean Coast Network are linked by their Mediterranean-type climate and are representative of Mediterranean-type ecosystems. Mediterranean-type ecosystems are distributed worldwide among five distinct geographical zones located along continental coastlines between 30º and 45º latitude. These include the Mediterranean Basin, the Cape region of South Africa, Central Chile, South and Southwestern Australia, and California. Hot dry summers and cool rainy winters typically represent the climate in these areas. Mediterranean ecosystems cover only about 3.0% of the world's land area, with more than 75% of this ecosystem type located in the Mediterranean Basin. Ten percent of the Mediterranean-type ecosystem occurs in California and northern Baja California. Vegetation communities in Mediterranean-type ecosystems are moisture and elevation dependent, and vary along a continuum from desert and semi-desert shrubs through savannas and grasslands, sclerophyllous woodlands, to coniferous and deciduous forests (see Figure 1.2) (Rundel, 1998a).

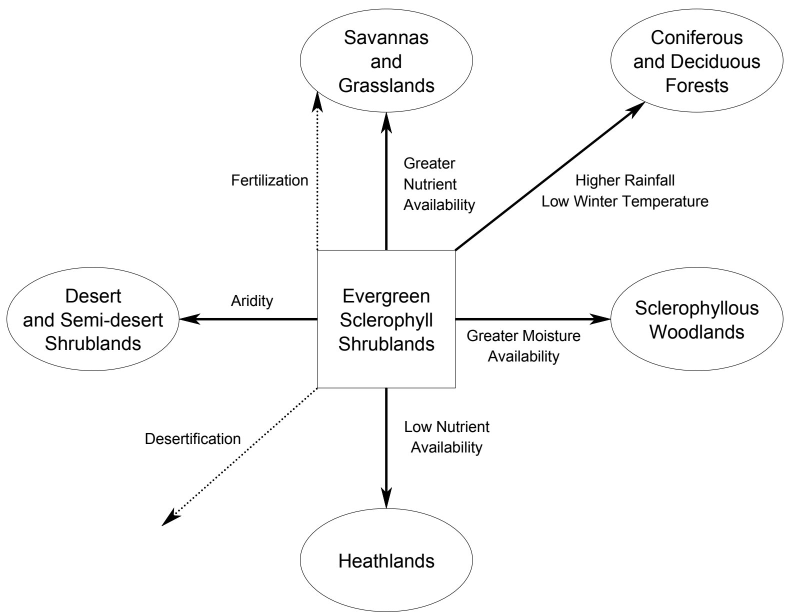

Figure 1.2 Distribution of Mediterranean-climate communities along environmental gradients of moisture availability, temperature, and soil nutrient availability. (Rundel, 1998a, adapted from di Castri, 1981).

Mediterranean-type ecosystems host a disproportionately large share of plant species worldwide in both the number of species and the number of rare or locally endemic species (Cowling & McDonald, 1998). All five Mediterranean-type regions support similar communities of broadleaf evergreen shrubs and dwarf trees known in North America as chaparral. Shrub oaks (*Quercus dumosa*), chamise (*Adenostoma fasciculatum*), red shank (*A. sparsifolium*), and California lilac (*Ceanothus spp.*) dominate California chaparral. Chaparral grades to coastal sage scrub dominated by drought deciduous shrubs at arid inland margins and along drier coastal areas. Coastal sage scrub is often an early successional community type following disturbance in Mediterranean-type ecosystems (Rundel, 1998a, *cf.* Dallman, 1998). Vegetation in each of the Mediterranean systems also shows similar adaptations to fire and low nutrient levels in the soils. For the most part, Chaparral lacks an understory, has little accumulation of ground litter, and is composed of highly flammable shrubs that produce abundant seed. Many species require the heat and scarring action of fire to induce germination (Smith, 1980).

Natural fire is a very significant factor in structuring Mediterranean-type ecosystems. California chaparral is extremely vulnerable to fire (Dallman, 1998) and well adapted to post-fire recovery with a well-described community dynamic process leading to complete recovery in as little as 10 years following a fire event (Table 1.1).

Table 1.1 Chaparral vegetation cycle following wildfire in southern California (c.f. Keeley & Keeley, 1986).

Years After Fire	Vegetation Response
1	(1) Explosive growth of long dormant seeds and bulbs. (2) Perennial herbs appear. (3) Sprouter and seeder shrubs slowly begin to re-establish.
2-4	Herbaceous perennial shrubs become more conspicuous.
5-9	Shrubs gradually become more dominant, leaving less space for other plants.
10-50	Dense shrub cover with scant understory becomes increasingly vulnerable to wildfires in late summer and early fall.

Vegetation community dynamics following fire in chaparral includes more than just changes in vegetation type. Fire, which is most common during late summer drought and associated with warm dry easterly Santa Ana winds, can burn vast areas of vegetation in a very short period of time. During a fire, ashing of vegetation releases minerals and nutrients into the soil, and hydrophobic substances that form a non-wetable layer at the soil surface are distilled onto deeper soil layers resulting in a shallow layer of wetable soil at the surface that erodes easily during winter rains. In addition, accumulated phototoxic compounds in the soil that inhibit germination, interfere with soil nitrification and litter decomposition are destroyed (Mooney & Parsons, 1973).

Shortly after a fire, even before winter rains begin, shrub species will resprout from underground lignotubers. In the first years after the fire an abundance of annual plants will also germinate and grow. “Fire-Type” annuals that are rare before a fire form masses of cover after a fire only to disappear again in a few years. Annual herbs, common prior to fire on rock outcrops or canopy openings, increase in numbers after a fire. Weedy annuals that are generally restricted to roadsides may invade recently burned areas (Mooney & Parsons, 1973).

1.6.2 Cabrillo National Monument

Cabrillo National Monument is located within the city limits of San Diego, California, on the southern end of Point Loma Peninsula (Figure 1.3). The peninsula which rises to a height of approximately 128 meters above sea level and is surrounded on three sides by the Pacific Ocean and San Diego Bay has been occupied by the U.S. military for much of the past 100+ years. In 1913 President Woodrow Wilson proclaimed a nearly 2,045 square meter parcel of land on Point Loma as a National Monument for the placement of an heroic statue of the Spanish Explorer Juan Rodriguez Cabrillo (Presidential Proclamation No. 1255, October 14, 1913). Subsequent presidential proclamations (Calvin Coolidge, No. 1773, May 12, 1926; Dwight Eisenhower, No. 3273, February 2, 1959; & Gerald Ford, No. 4319, October 1, 1974) and actions by congress have increased the size of Cabrillo National Monument to its present 66 hectares.

Point Loma's ecosystem occurs within the sixth largest city in the nation and is isolated from other natural land by the ocean and surrounding development that forms an effective island of rare habitats. Many of these habitats have been recognized as globally endangered or extremely endangered by the Natural Resource Diversity Database (1992) and include such communities as maritime succulent scrub, coastal sage scrub, and maritime chaparral. Nevertheless, the integrity of much of the coastal sage scrub community here is still considered to be very high. Point Loma’s protection as a federal reserve, where private development has not been allowed, and public access to much of the open lands has been restricted has limited disturbance to a relatively small portion of the point.

Figure 1.3 Cabrillo National Monument

Historically 19 species of reptile and amphibians inhabited the Point Loma area. Six of these species are now considered sensitive at the state or federal level. Herpetofauna inventories to document the baseline diversity, distribution, and abundance of the current reptile and amphibian community have been ongoing since 1995 (Atkinson, *et al.*, 2003). Sampling methodology and analysis procedures for this work are presently under review. The objectives of the review are to determine if the sampling design is robust enough to detect a 30% drop in species richness from historic levels, to detect a 30% drop in the relative abundance of orange-throated whiptail lizards (*Cnemidophorus hyperythrus*), and some measure of the drop in abundance of the western ring-necked snake (*Diadophis punctatus*) (Atkinson, *et al.*, 2003).

With over 1,000,000 visitors annually Cabrillo National Monument is one of the most intensively visited small parks in the National Park system. The bluff at Cabrillo National Monument provides panoramic vistas of the Pacific Ocean with great opportunities for observing the annual southward migrations of gray whales. Whale biologists take advantage of the topography of Cabrillo National Monument to census whales and observe their behavior during this annual winter migration. Additionally, Cabrillo's tide pools attract thousands of visitors, from school age to senior citizens and aesthetes to academics, to explore and research the wonders of one of the last remaining undisturbed rocky intertidal areas in the San Diego area. The Cabrillo tidepools also serve as important breeding grounds for owl limpets (*Lottia gigantea*) and other commercially important species in the area. Just offshore, outside of the park boundary, lie the Point Loma kelp beds, one of the most-studied kelp bed systems in the world. Unfortunately, San Diego Bay, bounding the peninsula on the east, has been listed as the second most polluted bay in the nation.

Over 1000 species of organisms, including over 80 sensitive species, reside in the marine and terrestrial environments of Point Loma.

Several federal agencies[5] hold ownership or stewardship over the lands on Point Loma. In 1994, these agencies, including the National Park Service (Cabrillo National Monument), developed a joint natural resources management plan and entered into a Memorandum of Understanding establishing the 634-acre Point Loma Ecological Reserve (PLER). The specific intent in creating the PLER was to "set aside sensitive biological communities in amounts and configurations that would be viable in the long term on Point Loma" (Anonymous, 1995). Of the 66 hectares that now make up Cabrillo National Monument, 52 hectares are included in the PLER. Additionally, Cabrillo National Monument manages nearly 52 hectares of marine intertidal on the western shore of Point Loma offshore of U.S. Navy land.

1.6.3 Channel Islands National Park

On April 26, 1938 Franklin D. Roosevelt by presidential proclamation (No. 2281) established the Channel Islands National Monument consisting of Anacapa and Santa Barbara Islands to protect "Fossils of Pleistocene elephants and ancient trees," and to preserve "Noteworthy examples of ancient volcanism, deposition, and active sea erosion." In 1949, President Harry S. Truman proclaimed the boundaries of Channel Islands National Monument to include the area within one nautical mile of the shoreline of Anacapa and Santa Barbara Islands (Proclamation No. 2825).

In 1976, Channel Islands National Monument entered into a memorandum of understanding with the U.S. Navy to assume management of San Miguel Island bringing the number of islands managed as a National Monument by the Park Service to three. In 1978, the three islands of the Channel Islands National Monument were designated a World Biosphere Reserve under the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Man and Biosphere Program. As a World Biosphere Preserve, Channel Islands National Monument was recognized internationally as an example of terrestrial and coastal marine ecosystems that demonstrate, "A balanced relationship between people and nature."[6]

In 1980, Congress created Channel Islands National Park from Channel Islands National Monument (6 U.S.C. 1 [§ 410ff.]) and stated that the "Channel Islands National Park … shall include San Miguel and Prince Islands, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands, including the rocks, islets, submerged lands, and waters within one nautical mile of each island."

Because of its exceptional natural beauty and resources, the Secretary of Commerce in 1980 designated a 1,252-square-nautical-mile portion of the Santa Barbara Channel as the Channel Islands National Marine Sanctuary. This sanctuary includes the waters that surround the islands of Channel Islands National Park from mean high tide to six nautical miles offshore. The sanctuary's primary goal is the protection of the natural and cultural resources contained within its boundaries.[7] In April of 2003, 10 designated areas of the Channel Islands National Marine Sanctuary were set aside as Marine Protected Areas where the taking of living, geologic, and cultural resources is prohibited (Figure 1.4). With the establishment of Marine Protected Areas within Channel Islands National Park and the Channel Islands National Marine Sanctuary there is renewed emphasis on resource monitoring within these areas especially as they relate to conditions assessing the effects of the enhanced level of protection.[8]

Channel Islands National Park (and the associated Channel Island National Marine Sanctuary and Marine Protected Areas) is a jeweled necklace of offshore islands and protected marine habitat that provides marvelous opportunities to experience the wonders of maritime associated terrestrial habitats and ocean resources. Channel Islands National Park consists of nearly 101,000 hectares half of which are

[5] U.S. Coast Guard, National Park Service, U.S. Fish and Wildlife Service, Department of Veterans Affairs, and the Point Loma Naval Complex.
[6] http://www.unesco.org/mab
[7] http://www.cinms.nos.noaa.gov/focus/about.html
[8] http://www.dfg.ca.gov/mrd/ci_ceqa/

submerged lands. The park's significance with respect to natural resources lies largely in the isolation of the islands which has resulted in the evolution of numerous species, subspecies, or varieties of unique flora and fauna. Over 2,000 species of plants and animals can be found within the park. One hundred and forty-five of these are unique to the islands and found nowhere else in the world. The Channel Islands are characterized by windswept landscapes, rugged coastlines, and unspoiled beaches. Wave-cut marine terraces, formed as changing sea levels and rising islands caused shorelines to recede, are a conspicuous landscape feature. Habitat types on the islands include coastal dune, coastal bluff, grasslands, coastal sage scrub, chaparral, island oak woodlands, mixed hardwood woodlands, conifer stands, riparian areas and wetland communities. The island flora includes several relict species such as the endemic island ironwoods (*Lyonothamnus floribundus*), and species such as the Torrey pine (*Pinus torreyana*). There is a high degree of endemism among the island flora with many species occurring on only one of the Islands. The physical difficulty of human access to the islands has provided some amount of protection to natural resources, and several species of marine birds and mammals which once commonly bred along the southern California coast now breed only on the Channel Islands.

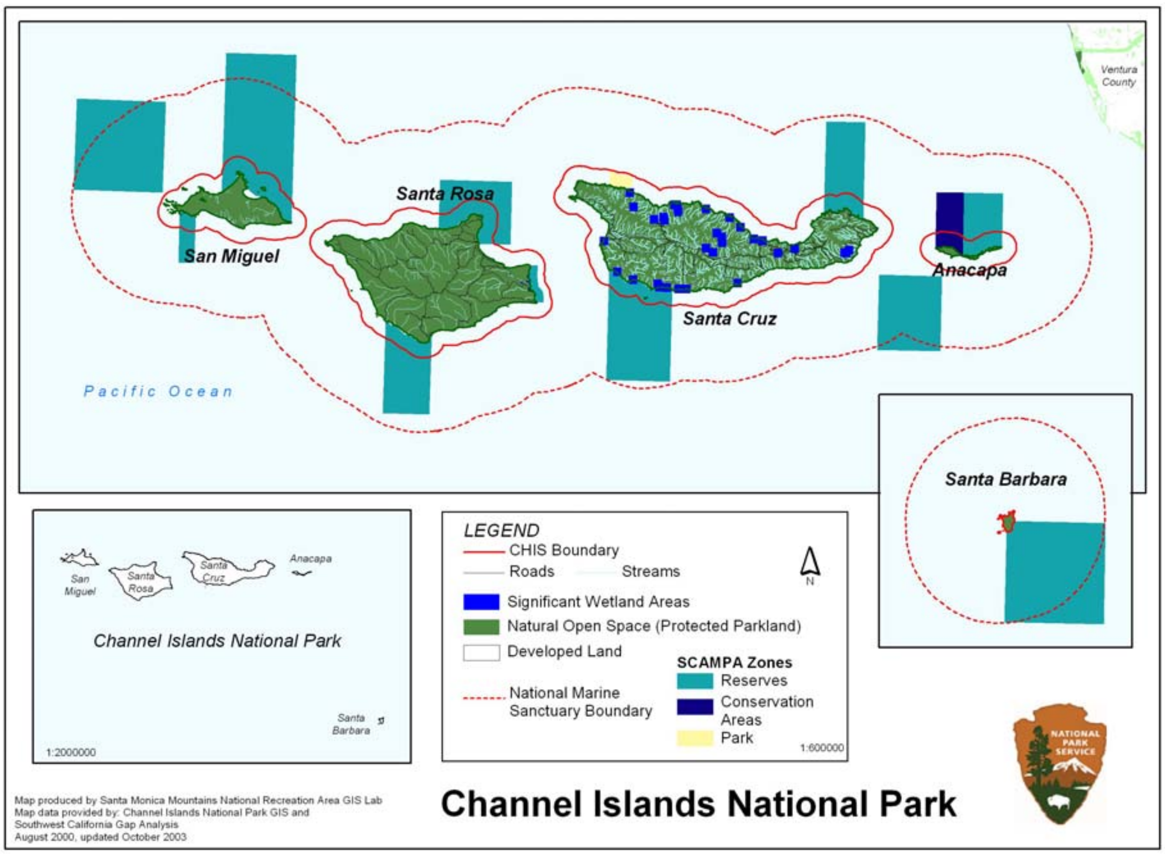

Figure 1.4 Channel Islands National Park, the boundary of the Channel Islands National Marine Sanctuary, and the boundaries of marine protected areas associated with Channel Islands National Park[9].

Coastal beach and associated dune habitats occur in the windiest sandy locations on all the northern islands and appear to be relatively undisturbed compared to their counterparts on the mainland. The coastal bluff, chaparral, coastal sage scrub, and mixed woodland communities support a very high number of rare plants.

[9] http://www.cinms.nos.noaa.gov/marineres/map.html

Not counting bats, 11 native vertebrate species inhabit Channel Islands National Park: two amphibians, two snakes, four lizards, two rodents, and two carnivores. The island fox (*Urocycon littoralis*) illustrates a typical case of island evolution wherein a species that occurs only on the Channel Islands is thought to have evolved from the mainland gray fox (*Urocycon cineroargenteus*). The Channel Islands have also developed some distinct avian forms, such as the Santa Cruz Island jay (*Aphelocoma insularis*), a distinct subspecies of non-migratory song sparrow residing on San Miguel Island, and several (10+) other endemic subspecies of birds in the islands.

Park waters contain a remarkably diverse array of ecological assemblages. Among the more prominent ecosystems surrounding the islands are forests of giant kelp (*Macrocystis pyrifera*), which inhabit relatively shallow rocky reefs. More than a third of all kelp forests in southern California occur in the park. These submarine forests provide food and shelter for more than 125 species of fish, and habitat for scores of other animals and plants, nearly 1,000 species in all. Eelgrass beds (*Zostera marina*) provide nursery habitat for juvenile fishes. Vast sand plains between the reefs host a variety of clams and other burrowing organisms. The deeper reaches of the park waters extend down to 300 meters or more as they trail off into submarine canyons. Many commercially important fish inhabit deeper waters of the park. Invertebrates, such as corals, sponges, and feather stars, cover deep reefs below the reach of sunlight.

At least 26 kinds of whales and porpoises can be found in the park, as well as five species of seals and sea lions. Many of these species are endangered. San Miguel Island is the only place in the world where four different species of pinnipeds regularly breed and the only area where five species are regularly found. San Miguel's Point Bennett is the location of one of the world's most outstanding wildlife displays, with thousands of seals and sea lions hauling up on it’s sandy beaches to breed, pup, and molt. At least 15 species of seabirds or shorebirds are known to nest in the park.[10] These Channel Islands colonies are significant contributors to maintaining global populations of many of these species.

1.6.4 Santa Monica Mountains National Recreation Area

In 1978 Congress established The Santa Monica Mountains National Recreation Area recognizing the value of the geological, biological, archeological, historical, sociological, recreational, and scenic resources of the Santa Monica Mountains and adjacent seashore, and the vulnerability of these resources to impacts from their proximity to a large urban and suburban population. Congress also “found that there are … public health benefits provided by the Santa Monica Mountains and adjacent coastline area, (and that) there is a national interest in protecting and preserving these benefits for the residents of and visitors to the area.” In creating Santa Monica Mountains National Recreation Area, Congress charged the Secretary of the Interior to “manage the recreation area in a manner, which will preserve and enhance its scenic, natural, and historical setting and its public health value as an airshed for the Southern California metropolitan area while providing for the recreational and educational need of the visiting public” (16 U.S.C. 1 [§ 460kk]) (Figure 1.5).

[10] http://www.nps.gov/chis/

The Santa Monica Mountains are the southernmost mountain chain in the east-west trending, or "Transverse" Ranges of southern California. The Transverse Ranges are characterized by numerous faults, folds, downwarps, and a complex geologic structure. There are no natural freshwater ponds or lakes, but streams and springs are abundant in the mountains.

Figure 1.5 Santa Monica Mountains National Recreation Area

The Santa Monica Mountains National Recreation Area is the largest urban park in the United States, and represents one of the largest and most significant areas of protected Mediterranean-type ecosystem in the world. The park exists today as a mosaic of different land ownerships and land uses extending over 60,750 ha. Of that amount, 29,495 ha (≈ 48%) are currently in protected status through public ownership (8,753 ha [≈ 15%] are owned and managed by the National Park Service). The remaining 31,255 ha (≈ 52%) are in private ownership. Unlike most national parks, Santa Monica Mountains is still expanding as remaining open space around the park and within the boundaries of the park becomes available and is purchased for protection as public parkland. Included within its boundaries are the famous Hollywood sign, the city of Malibu, the Santa Monica Pier, and several large and popular state parks and beaches. Five U.S. Zip Codes are located within the park including the famous 90210 (Beverly Hills). A unique climate, diverse topography, and other factors create a complex assemblage of vegetation types within the mountains. This vegetation diversity provides abundant habitat for numerous animal species. These natural resources occur within and adjacent to Los Angeles, the second largest urban area in the nation.

The aquatic resources of the Santa Monica Mountains are very diverse. Dozens of north-south canyons parallel each other throughout the Mountains. Each of these has an intermittent or perennial stream, with associated riparian vegetation. In addition, there are a large number of east-west trending drainages sliding off the slopes of these canyons. A wide variety of localized plant communities can be found associated with the streams of the Santa Monica Mountains. These include remnant populations of big leaf maples, cottonwoods, and alder.

From Mugu Lagoon to the Santa Monica Pier, the Santa Monica Mountains National Recreation Area boundary includes 41 miles of Pacific coastline down to the mean high tide line. A variety of upland habitats, coastal bluffs, sand dunes, rocky and sandy beaches, the ends of perennial and intermittent creeks and several lagoons are included within the park boundary. Although not included within the park, the nearshore habitats are also diverse in structure and species composition, and include rock reefs, tidepools, kelp beds, submarine canyons and subtidal sand flats.

Twelve vegetation community types derived from twenty-six vegetation associations as identified by the California Natural Diversity Database (Holland, 1986) classification system occur in the Santa Monica Mountains. These include: Coastal Salt Marsh, Coastal Strand, Coastal Sage Scrub, Chaparral, Coast Live Oak Woodland, Riparian Woodland, Valley Oak Savanna, Valley Grassland, Freshwater Ponds, Lakes, Rock Outcrops, and Suburban Development.

More than 450 vertebrate species occur in the park, including 50 mammals, 384 birds, and 36 reptiles and amphibians. The relatively intact wildlife populations of the Mountains are unique in their proximity to one of the largest urban areas in the United States. Mule deer are the largest herbivore in the Santa Monica Mountains. There are three species of lagomorphs, including the Brush Rabbit, Audubon's Cottontail and the Black-tailed Jackrabbit. Common species of rodents include: the California ground squirrel, Fox squirrel, deer mouse, dusky-footed woodrat, Pacific kangaroo rat, and the pocket mouse. The Santa Monica Mountains still support mountain lions. Intermediate sized predators include: bobcats, gray foxes, badgers, and long-tailed weasels. Omnivorous predators in the mountains include: coyotes, ring-tailed cats, raccoons, and spotted and striped skunks. Harbor seals breed in Mugu lagoon.

Of the total number of birds that are found within the park, approximately one-third breed there. Thirteen of these breeders are raptors. Currently, golden eagles, red-tailed hawks, red-shouldered hawks, Cooper's hawks, sharp-shinned hawks, prairie falcons, American kestrels, black-shouldered kites, barn owls, great horned owls, western screech owls, burrowing owls, short-eared owls, and turkey vultures nest within the park.

Twenty-five species of reptiles inhabit the Santa Monica Mountains, including two turtles (one introduced), seven lizards and sixteen snakes. The Santa Monica Mountains contain habitat for eleven species of amphibians, including five salamanders and six (two introduced) frogs or toads. A variety of native and introduced fishes occur in the waters of the Santa Monica Mountains. Of significance are at least two spawning populations of steelhead trout and one spawning population of Pacific lamprey. There are several beach locations where California grunion regularly spawn. Arroyo chub occur in the slow moving waters of Malibu Creek and a variety of introduced fish, such as largemouth bass, bluegill and goldfish occur in freshwater streams up and downstream from recreational lakes and golf course such as Malibu Lake and the Malibu Country Club.

Twenty-three permanent or seasonal resident plant and animal species of the Santa Monica Mountains National Recreation Area are federally listed as threatened or endangered. One of these, the California Condor, is currently extirpated, but could occur again, depending on the success of ongoing breeding and reintroduction programs administered by the U.S. Fish and Wildlife Service and the U.S. Forest Service. Two additional state-listed species occur within the Santa Monica Mountains. Another forty-nine species are candidates for federal listing or have been proposed for listing by the U.S. Fish and Wildlife Service.

The Santa Monica Mountains represent an island of biodiversity and open space refuge within an ever expanding landscape of urban and suburban development.

1.7 Service-wide Goals for Monitoring

Service-wide goals of the monitoring program that are to guide development of individual network monitoring programs are:

1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
4. Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
5. Provide a means of measuring progress towards performance goals.

1.8 Inventory & Monitoring Goals for Performance Management

1.8.1 National GPRA Inventory & Monitoring Goals

The Government Performance and Results Act (GPRA) of 1993 requires that all government agencies develop strategic management plans that embrace performance measurement as a guiding management principle. National level long-term GPRA goals for the Park Service (to be achieved by 2005) as related to natural resources and the Inventory and Monitoring Program include the restoration of 9100 hectares of lands disturbed by development or agriculture, improve the status of 84 populations of federally listed threatened or endangered species, plant and animal species of special concern as identified by individual parks are at acceptable levels, air quality in 70% of reporting parks has remained stable or improved, 85 % of 265 park units have unimpaired water quality, and of most importance to the Inventory and Monitoring Program 87% of the basic natural resource inventory datasets outstanding in 1999 are completed, and 80% of 270 parks with significant natural resources have identified their vital signs for natural resource monitoring (NPS, 2000a). Meeting most of these goals will be accomplished by the combined efforts of park and resource managers working in individual parks throughout the country. While the completion of the inventory datasets is a combined effort of Washington Support Office staff and park personnel, identifying vital signs is a network based program that is the focus of chapter three in this monitoring plan.[11]

1.8.2 Inventory & Monitoring Goals in Park Management Plans

Each unit of the Park Service (support offices and parks) has developed their own set of GPRA goals relative to their respective missions. Park specific GRPA goals and general resource management goals relative to the Inventory and Monitoring of natural resources for Mediterranean Coast Network parks include:

1.8.2.1 Cabrillo National Monument

The Cabrillo NM Resources Management Plan identifies the proposed expansion of the Blom Wastewater Treatment Plant, a close neighbor on the western shore of Point Loma, as the most significant outside threat to park resources and as such proposes to establish a long term monitoring program for marine water quality in the park. This program is to include the hiring of a resource management specialist to advise park management on the impacts of, and management actions required to ameliorate the

[11] See 3-phase approach to designing a monitoring program, May 2, 2002 at http://www1.nrintra.nps.gov/im/monitor/

expansion and continued operation of this facility. Another primary concern of resource managers is the condition of the coastal sage scrub vegetation community that dominates the park landscape. A program to inventory and categorize the vegetation community is to be initiated to provide baseline information for the development of long-term monitoring protocols for assessing the health of this important park resource.

Other significant resources of concern to managers at Cabrillo National Monument are the status of its tidepools. Cabrillo National Monument manages one of the last rocky intertidal areas open to the public in Southern California, and has instituted a long term monitoring program to assess tide pool health. Other resource concerns mentioned in the Resources Management Plan include:

1. Monitoring of air quality for impacts on viewshed deterioration resulting from anthropogenic sources associated with the City of San Diego,
2. Eliminating, where possible, alien vegetation from the park. Specifically to remove ice plant and to restore coastal sage scrub vegetation
3. Monitor soil erosion and develop mitigation plans to conserve soil resources,
4. To develop interagency plans for the management of sensitive ecological resources within the Point Loma Ecological Reserve, and
5. To monitor visitor use patterns and their impacts on natural resources within the park.

Specific GPRA goals for Cabrillo National Monument related to the Inventory and Monitoring program that are to be met by September 30, 2005 include: (1) 3 of 6 hectares of Cabrillo National Monument's land impacted by exotic vegetation targeted by September 30, 1999 is contained through the removal of *Carpobrotus* (ice plant), *Acacia*, *Eucalyptus*, yellow star thistle (*Centaurea solstitialis*), Russian thistle (*Salsola australis*), and other non-native plants. (2) The relative abundance of 7 intertidal species is increased 10% above 1996 levels. (3) 27 (10%) of 267 hectares of the Point Loma Ecological Reserve's targeted lands impacted by exotic vegetation as of Fiscal Year 1999 are contained through the removal of *Acacia*, *Carpobrotus*, *Eucalyptus*, tree tobacco (*Nicotiana glauca*) and other non-native plants. (4) Cabrillo National Monument has identified its vital signs for natural resource monitoring. (5) Research reports describing the condition through monitoring of two taxonomic groups (reptiles & amphibians, and vegetation) in terrestrial habitats are published and available to the public. (6) Five of 20 primary Cabrillo NM/Point Loma Ecological Reserve natural resource inventories identified in the monument's Resource Management Plan are completed.

1.8.2.2 Channel Islands National Park

The Channel Islands National Park 1999 Resource Management Plan has as its stated objective to "Plan for the long-range management of its resources," and includes tactical plans for short-term projects. This plan "Identifies and describes specific inventory, monitoring, research, restoration, and mitigation actions … needed to perpetuate natural processes and resources … in Channel Islands National Park." A general goal of resource management and the monitoring program is to restore the terrestrial ecosystem to a condition reminiscent of the period before European man began altering the islands (Channel Islands Resource Management Plan, 1999).

Specific monitoring goals from the Channel Islands Resource Management Plan include:

1. Knowing and understanding the status and trends of resources, natural processes, and threats to resource integrity,
2. Restoring impaired resources and processes,
3. Protecting resources from harm, and
4. Partnering with agencies, organizations, and individuals to better achieve the park mission.

The specific GPRA goal for Channel Islands National Park as related to the Inventory and Monitoring program that is to be met by September 30, 2003 states that monitoring for eleven of fourteen vital signs has been implemented and resources are being monitored in at least a portion of the park. To date monitoring of eleven[♣] of the fourteen vital signs identified for Channel Islands National Park has been begun and is ongoing in at least a portion of the park. Vital signs identified for Channel Islands National Park are: Pinnipeds*, Rocky intertidal communities*, seabirds*, landbirds*, marine invertebrates*, marine vegetation*, marine fish*, terrestrial vegetation*, weather*, terrestrial mammals[†], amphibians and reptiles[†], water quality[‡], fisheries[‡], and terrestrial invertebrates[‡].

[♣]Terrestrial mammals monitoring has stopped in recent years with the departure of qualified personnel to conduct the monitoring.

*Monitoring implemented, [†]Monitoring protocols in place, and monitoring will start as funding becomes available. [‡]Low priority vital signs, monitoring protocols yet to be prepared, with no immediate plans for implementation.

1.8.2.3 Santa Monica Mountains National Recreation Area

“Preservation of Santa Monica Mountains National Recreation Area’s natural … resources requires a long-term perspective and commitment to protect the ecological integrity of the park. Preservation of the ecological viability of the entire ecosystem, not simply specific biological ... features, is a significant aspect of National Park Service policy in the Santa Monica Mountains National recreation Area” (Santa Monica Mountains National Recreation Area Resource Management Plan, 1994). This philosophy was reiterated in the 1999 resource management plan which states that the “first goal of the park’s resource stewardship program (is) to obtain knowledge and understanding of (the) natural … resources of the Santa Monica Mountains National Recreation Area.” The 1999 Resource Management Plan states further that “It is critical for park managers to evaluate trends in resource conditions over time,” and that the way to meet this objective is to “identify vital signs of ecosystem condition and monitor them to detect potentially important changes over time.” Specific vital signs monitoring goals identified in the resource management plan include:

1. Determining the status and trends of ecosystem health,
2. Establishing empirically normal ranges of variation of ecosystem resources,
3. Providing early diagnosis of abnormal conditions that require intervention, and
4. Identifying potential agents of abnormal change to guide research and prescribe treatments.

Additionally, and as part of a broader goal to obtain knowledge and understanding of natural resources, “a vital signs monitoring program is being established as an integral objective of the park’s resource stewardship program.”

Specific GPRA goals for Santa Monica Mountains National Recreation Area as related to the Inventory and Monitoring program that are to be met by September 30, 2005 include: (1) Twelve of 2,430 hectares of targeted lands disturbed by prior physical development or agricultural uses, as of Fiscal Year 1999, are restored. (2) Exotic vegetation on 156 of 1,560 of targeted hectares of lands is contained. (3) One in five of the Fiscal Year 1999 federally listed and endangered species with critical habitat or requiring recovery actions have stable status. (4) Location and status of 21 of 143 plant and animal species of special concern are known and documented. (5) Water quality and exotic species in 30 streams will be monitored. (6) Ten of twelve primary natural resource inventories are completed. (7) Vital signs for natural resource monitoring are identified.

1.9 Significant Management & Scientific Issues in Network Parks

As with other Mediterranean climate regions, southern California is favorable to human habitation, agriculture, and recreational activities. These human influences have dramatically affected the health of ecological systems and individual species within the region. The high degree of continuing urbanization along the coastline has resulted in the loss of many significant natural areas (Mac, *et al.* 1998). Several common plant communities of the Southern California Mediterranean-type ecosystem are identified as being very sensitive to environmental perturbation (Lock-Dawson, 2000). Within the context of natural open space preservation, all areas of native vegetation are important to resource managers and efforts are underway to protect them from invasion of exotic plant species, impacts from undue visitor use, habitat type conversion, and encroachments from development. In addition, the ever shrinking amount of open space has seriously fragmented the natural landscape posing significant problems for many species dependent upon large contiguous areas of habitat. For this reason habitat type conversion, habitat connectivity, and barriers to migration have become major issues for park managers as they respond to development and urban growth within and adjacent to network parks.

1.9.1 Cabrillo National Monument

For its small size Cabrillo has taken on significant importance in protecting an example of an ecosystem transitioning from one dominated by coastal sage scrub species to one that included several Baja California succulents. Natural resource protection within Cabrillo National Monument is the result of its serendipitous preservation as a site of national historical value, and the role the National Park Service takes in managing the site. Point Loma's complete insularization by development has isolated several relict populations of meso-carnivores, reptiles, amphibians, and raptors, and provides a significant stopover point for many species of migratory birds. Cabrillo NM also protects and manages one of the last relatively undisturbed marine intertidal areas in the San Diego area. Protection and restoration of critical coastal sage succulent scrub and the marine intertidal have been embraced as significant responsibilities of park staff in all aspects of park management. Little did the Presidents who created and expanded the size of Cabrillo National Monument visualize the importance their actions would be in preserving natural open space with such strategic ecological value in the ever expanding urban Landscape of San Diego, California.

As mentioned elsewhere (§ 1.8.2.1) the close proximity of the Blom Waste Water Treatment Plant to the rocky intertidal at Cabrillo is always a concern for its potential degradation of marine water quality and impacts on the intertidal biota. A major spill of treated effluent from the plant in 1992 resulted in the closing of the tidepools to visitors for nearly three months and caused untold damage to the marine environment. Quality of the surrounding marine waters and the ecological integrity of the marine intertidal community have been concerns of local natural resource managers for many years and a long-term monitoring of intertidal resources began in 1990 with experience and methodology that was exported from Channel Islands National Park (Becker, 2003, Appendix II). The goals of this program are:

- To collect long-term, baseline information on the "ecological health" of the rocky intertidal area, and to determine normal limits of variation.
- To determine differences between three zones of controlled access, which experience very different amounts of visitation, and to determine the effects of the closure of Zone III to the public.
- To be comparable and compatible with existing data and similar programs in southern California (e.g., Channel Islands National Park and the Multi-Agency Rocky Intertidal Network [MARINE]).
- To detect large changes in community structure reasonably quickly.
- To provide baseline data in case of an acute disturbance (e.g., oil spill or sewage spill), and to serve as an opportunity for public education and outreach.

Point Loma has been occupied by the U.S. military for much of its modern history. Relict coastal gun emplacements and bunkers from World War II are part of the landscape of Point Loma and Cabrillo National Monument. These patches of disturbance, their supporting infrastructure and access roads have facilitated significant invasions of exotic vegetation to the area. Efforts to restore these areas to native habitat are ongoing and play and important role in resource management activities for Cabrillo National Monument. A small pack of gray fox are resident on the very tip of Point Loma and are kept isolated by urbanization and cosmopolitan coyotes that roam between available open space and the adjacent military reservation and residential neighborhoods. While there is a single nesting pair of Peregrine Falcons resident on the point many other species of raptors are frequently observed within the park and reserve.

1.9.2 Channel Islands National Park

Channel Islands NP was created, "In order to protect the nationally significant natural, scenic, wildlife, marine, ecological, archaeological, cultural, and scientific values of the Channel Islands in the State of California, including, but not limited to, the following:

1. The brown pelican nesting area;
2. The undisturbed tide pools providing species diversity unique to the eastern Pacific coast;
3. The pinnipeds which breed and pup almost exclusively on the Channel islands, including the only breeding colony for northern fur seals south of Alaska;
4. The Eolian landforms and caliche;
5. The presumed burial place of Juan Rodriquez Cabrillo; and
6. The archaeological evidence of substantial populations of Native Americans."

The introduction of exotic alien species, both plant and animal, to the Channel Islands during periods of past human habitation has resulted in varying and significant changes in the natural ecosystems and ecosystem processes on the islands. One of the major management practices within Channel Islands National Park has been the removal of alien species and the reintroduction of extirpated species in an effort to shift the islands ecosystems toward a naturally functioning and self-regulating condition. Past alien species eradication programs have included the removal of rabbits from Santa Barbara Island, burros from San Miguel Island, sheep from Santa Cruz Island, and pigs from Santa Rosa Island. A program to eradicate alien rats from Anacapa Island has just been completed, and eradication of feral pigs from Santa Cruz Island is expected to begin in early 2004. Elk, deer, and horses on Santa Rosa Island are being managed under a special use permit and will likely be removed by the end 2011. Reintroduction of extirpated species is also underway. Bald eagles and peregrine falcons have been reintroduced to Santa Cruz Island, and the northern island tree mallow was recently reintroduced to the park.

1.9.3 Santa Monica Mountains National Recreation Area

While 90% of Santa Monica Mountains National Recreation Area contains relatively undisturbed natural habitat, more than half of this area is privately owned. The greatest threats to natural resources within the park are impacts associated with transformation from natural open space to developed areas. In many other parks and reserves, land within the legislated boundaries is completely or nearly completely federally owned and both external and internal development threats are less severe.

Santa Monica Mountains National Recreation Area with its intermixing of publicly owned and privately owned open space, and urban and rural development has instituted a rigorous ecosystem based resource management strategy that has mimicked in some degree the intent of the vital signs monitoring program. Resource managers from the Santa Monica Mountains National Recreation Area have established significant and ongoing cooperative research and monitoring efforts with the U.S.G.S. Western Ecological Research Center, several local universities, and State of California resource management agencies. The primary goals of the resource management program at Santa Monica Mountains NRA are ecosystem based and directed at maintaining ecosystem functionality not only within the NRA but within the general southern California landscape of which it is an important constituent.

One important task for the park resources management program is to identify the most significant, undisturbed natural resources in the Santa Monica Mountains. Information on the status and distribution of park resources is a critical pre-requisite for ensuring their protection. Alien plant invasion, hydrologic alterations, poor land management practices, vegetation type-conversion, and loss of habitat resulting from increased fire frequency, impacts from visitor use, and impacts from residential development (e.g., light pollution, increased traffic, etc.) combine to make preservation of natural resources in this area more difficult than in most other comparable natural areas.

Because of prototype monitoring activities at Channel Islands NP, natural resource managers at Santa Monica Maintains NRA recognized the desirability of establishing local inventory and monitoring activities even before the service-wide formalization of this program. Santa Monica Mountains focused it's resource management program on top priority needs as defined in the park's Resource Management and Land Protection Plans. As a result, a number of soft-funded and base-funded monitoring efforts were established that focused on areas of immediate conservation and resource management concern. For example, since 1995, extensive mammalian carnivore monitoring has been conducted to evaluate habitat fragmentation effects on park resources. Rare plant inventories and monitoring were conducted to aid in land protection planning and site-specific resource management. Although a formal national-level inventory and monitoring funding mechanism was not yet in place to support these efforts, the park chose to pursue them out of management necessity. Resource managers within Santa Monica Mountains National Recreation Area have also identified the following specific objectives for measuring the effectiveness of their efforts as:

1. No expansion of crayfish distribution into new streams.
2. Elimination of exotic species from individual streams, including crayfish and exotic fish.
3. Identify the percentage of urban runoff in streams, and reduce these inputs.
4. Maintain newt, California tree frog, pond turtle, and two-striped garter snake distributions at current levels.
5. Maintain bat diversity at current levels.
6. Maintain terrestrial reptile and amphibian diversity at current levels.
7. Maintain migratory and resident nesting bird diversity at current levels.
8. Maintain successful raptor breeding at current levels.
9. Maintain small mammal diversity at current levels.
10. Maintain bobcat breeding in habitat fragments at 2002-2003 levels.
11. Reduce mortality of bobcats and coyotes from anti-coagulant poisoning.
12. Decrease coyote/human complaints/conflicts by 50%.
13. Decrease road-kill on the 23 freeway by 50%.
14. No further loss of connectivity between major habitat areas, i.e. between the Santa Monica Mountains and the Simi Hills, and between the Simi Hills and the Santa Susana Mountains.
15. Increase the number of usable wildlife connections between the above areas.

With the availability of vital signs funding and the network approach, the existing programs at Santa Monica Mountains are being evaluated in the broader network-wide context. Based on the results of this evaluation, and through workshops and network meetings, existing efforts may be modified and/or expanded to reflect park-specific priorities and network goals and objectives.

1.9.4 Resource Management Partnerships within the MEDN

Because of the proximity of network parks to large urban centers with several universities, conservation associations, state and federal resource management agencies, and other governmental entities myriad opportunities abound to partner for resource stewardship, management, and study. Each of the three parks within the network has established formal relationships with many of these groups or agencies to further their resource management mission.

1.9.4.1 Cabrillo National Monument

Cabrillo National Monument has entered into a Memorandum of Understanding with the U.S. Coast Guard, U.S. Fish and Wildlife Service, the Department of Veterans Affairs, the City of San Diego, California, and several command authorities of the U.S. Navy to implement a joint Resource Management Plan for the Point Loma Ecological Reserve. The intent of this agreement and resource management plan is to insure the long-term viability of sensitive biological communities on Point Loma peninsula, and to allow land owners on Point Loma to meet their respective missions while complying with the requirements of environmental legislation such as the National Environmental Policy Act and the California Environmental Quality Act.

1.9.4.2 Channel Islands National Park

Channel Islands National Park has entered into several agreements and associations for the management of natural resources within the park. Among these are: An Interagency Agreement with the U.S.G.S. Biological Resources Division for operation of the Channel Islands Field Station; Memoranda of Agreements with the State of California – Department of Fish and Game, The Nature Conservancy for the management of the Santa Cruz Island Preserve, the U.S. Fish and Wildlife Service for conservation of biological diversity and the recovery and protection of special status species and coordinated resource management planning, and the U.S. Navy for the administration of San Miguel Island; Memoranda of Understanding – with The Nature Conservancy for research, education, and management of natural resources within the Santa Cruz Island Preserve; the Santa Barbara County Air Pollution Control District; the Naval Air Warfare Center; the Environmental Protection Agency and the California Air Resources Board for Meteorological and Ozone monitoring on Santa Rosa Island; the National Marine Fisheries Service for management of pinnipeds and the State of California for the scientific collection of fish and invertebrates.

1.9.4.3 Santa Monica Mountains National Recreation Area

Santa Monica Mountains NRA benefits from a Memorandum of Understanding with the U.S.G.S. to facilitate management and interpretation of geological resources within units of the National Park System. Santa Monica Mountains NRA has also entered into a memorandum of understanding with the Mountains Recreation and Conservation Authority. Several informal links and cooperative agreements are in place with the University of California Los Angeles, California State University Northridge, Pepperdine University, University of California Santa Barbara, University of Southern California, San Diego State University, and California State University Los Angeles that allow university researchers and students to cooperate with park resource staff in better understanding and managing mountain resources.

An interagency agreement between Santa Monica Mountains National Recreation Area and the Point Mugu Naval Air Weapons Station formalizes National Park Service interest in the natural resources of Mugu Lagoon, a coastal wetland at the extreme western tip of the park. Various other Memoranda of Understanding for resources management in the Santa Monica Mountains National Recreation Area include:

- Los Angeles County Weed Management Area
- California Dept of Fish & Game
- California Dept of Food and Agriculture
- California Dept of Parks & Recreation
- California Dept of Transportation
- California State Polytechnic University, College of Agriculture, Pomona, California
- U.S.D.A. Natural Resources Conservation Service
- U.S. Army Corps of Engineers
- Bureau of Land Management
- Resource Conservation District of the Santa Monica Mountains
- Los Angeles & San Gabriel Rivers Watershed Council
- Mountains Restoration Trust
- San Gabriel Mountains Regional Conservancy
- California Alien Pest Plant Council
- California Native Plant Society
- Las Virgenes Institute for Resource Management

1.9.5 Important Agents of Change & Stressors in Network Parks

The effects of environmental process are the driving forces of evolution. Individual species morphology, environmental tolerances, nutritional requirements, and habitat preferences are the results of long term environmental conditions that operate over a scale of at least 10^5 or 10^6 years and reflect the processes of natural selection. Evolution of ancestral angiosperm plants into various shrub forms is generally thought to have been the result of multiple types of environmental stresses (see Figure 1.6) (Rundel, 1991). For example, regular drought and fire stress are thought to have been the factors that resulted in the drought-tolerant and fire-dependent reproductive strategies characteristic of Mediterranean-type shrub and grassland communities.

Ecosystem disturbance in southern California can be traced to the earliest human inhabitants. Native Americans became widespread in California from 6,000 to 10,000 years ago, and are known to have had a significant effect on native vegetation through harvesting of food, fiber, and building materials and by the use of fire to drive game or to convert shrublands to grasslands for grazing large animals (Rundel, 1998b). While settlement in California by European peoples prior to the Gold Rush of 1848 was quite limited, cattle and sheep ranching were widespread in the region and resulted in the conversion of plant communities from native perennials to alien Mediterranean Basin annuals (Rundel, 1998b). During the 1880's cattle and sheep ranching diminished and the clearing of lands for agriculture and urbanization began and has continued exponentially to the present (Rundel, 1998b; Quinn, 1998). Reduction in fire frequency, by active suppression, has resulted in increased fire intensity in chaparral and woodlands, and has been a major community changing process in the Mediterranean-climate region of California (Rundel, 1998a).

Groves (1998) has identified several factors that are indicators of landscape degradation in Mediterranean-type ecosystems. These include:

1. A decrease in the rate of vegetative litter accumulation
2. An increase in the rate of soil erosion
3. Invasion of light-demanding alien plants
4. A decrease in the cover of perennial native vegetation and an increase in the cover of alien annual plants
5. Changes in the general phenology of vegetation communities
6. An increase in fire frequency
7. An increase in the woody elements of vegetation or the proportion of post fire plants that recover by resprouting.

Ecosystem stress or disturbance in southern California can be categorized as intrinsic or extrinsic. Intrinsic stresses, originating naturally (climate, earthquake, extreme storm events, and especially fire) are part of the normal Mediterranean-type ecosystem structuring process. Extrinsic stresses are the result of human urbanization, development, agriculture, and recreation. The occurrence and intensity of natural stresses or disturbance such as fire can be altered by human activities. The result is that the natural post-fire recovery processes may be impacted to such an extent that the normal post-fire dynamics is changed resulting in the establishment of a persistent vegetation community that is much different than would have developed under natural fire conditions.

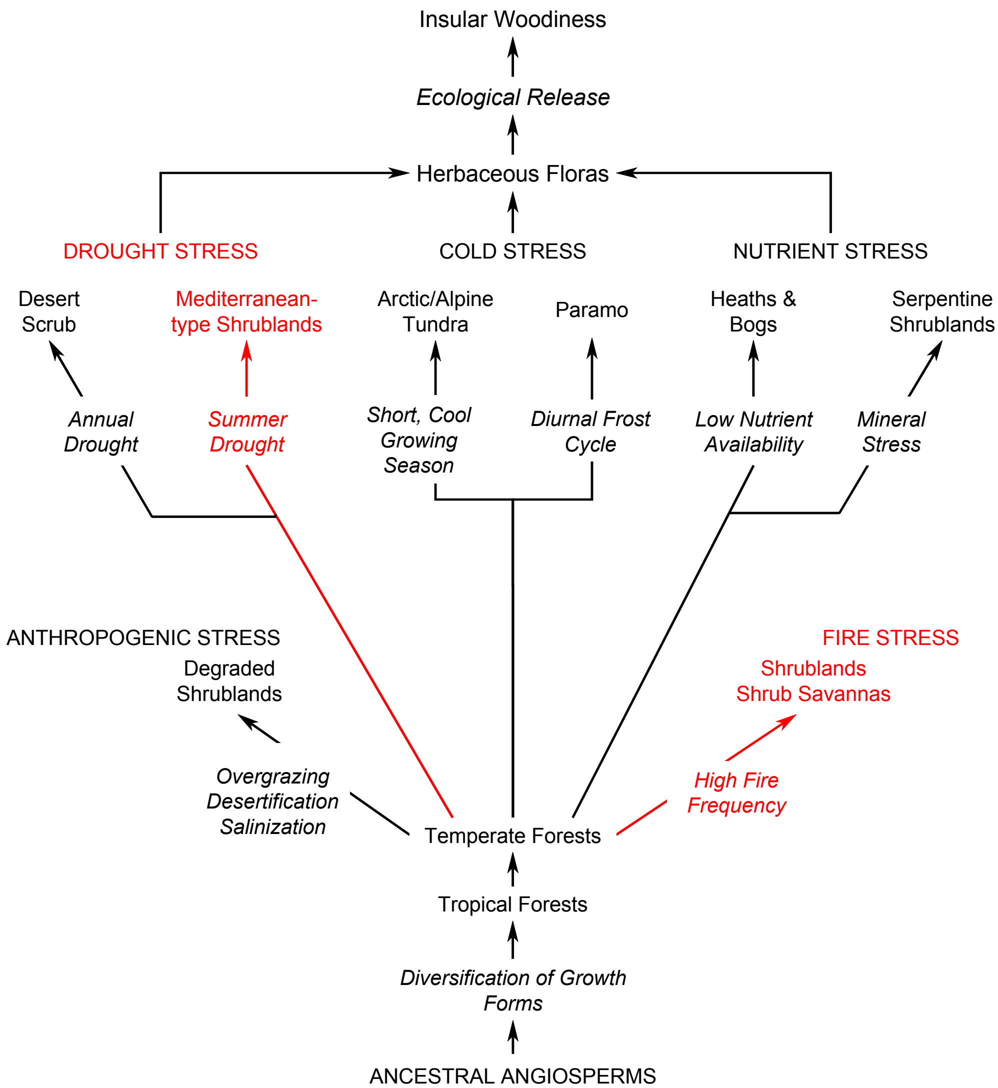

Figure 1.6 Evolutionary tree for the development of communities dominated by shrub life-forms under multiple environmental stresses (Rundel, 1991). Pathways leading to Fire and Drought resistant species are highlighted in red.

Intrinsic and/or extrinsic stress and/or disturbance may also be chronic or acute in action. Mediterranean-type ecosystems are inherently chronically stressed by both types of stressors as well as interactions among these stressors. The differentiation of a stress or disturbance as either chronic or acute is dependent upon the temporal and spatial scale of the stress or disturbance. Air quality impacts, landslides and debris flow, ongoing small scale development, alien species invasions, light pollution, noise pollution, roadway mortality, and hazard fuel reduction are among the significant chronic stressors impacting network parks. Chronic stress and disturbance is responsible for much of the structure and function (integrity) of modern Mediterranean-type ecosystems. Specific acute ecosystem impacting stresses that occur as extreme disturbance events within southern California and that can significantly alter the local ecosystem of the parks of the Mediterranean Coast Network include: extreme microclimate weather events, urban development, frost, fire, El Niño, extreme drought, and earthquakes (Figure 1.7).

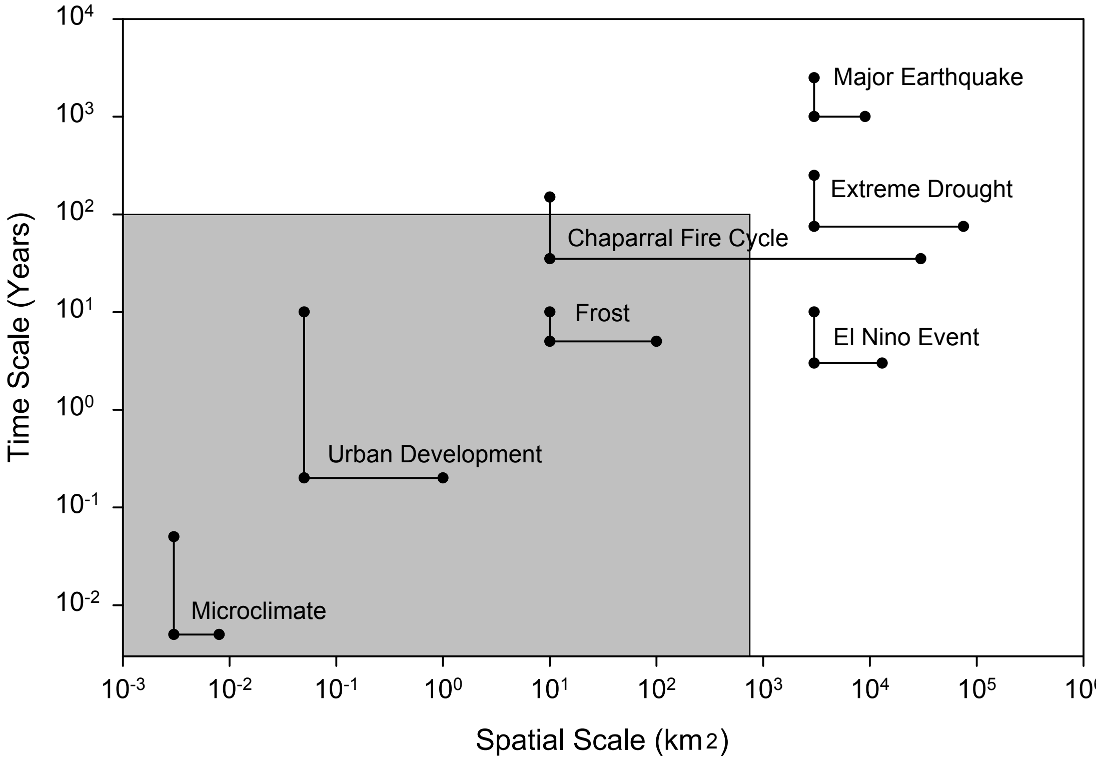

Figure 1.7 Spatial and temporal scale representations for extreme disturbance events that can result in changes in the composition and structure of the Southern California Mediterranean-type ecosystem.

For reference Figure 1.7 also plots a temporal limit of 100 years and a spatial scale of 600 km^2 (the gray area) as a reasonable point of comparison for establishing spatial and temporal monitoring limits within the MEDN. While extreme events that occur or reoccur on a time scale of 100 years or more are probably not practical to monitor, spatial limits to monitoring are not as easy to address in the context of extreme disturbance events. The gray area of the graph is limited to 600 km^2, which is approximately the area of Santa Monica Mountains NRA. A major earthquake affecting thousands of km^2 would be a structure-altering event with variable impacts across the impacted area. The impacts of an individual earthquake are dependent upon its magnitude, intensity, and proximity to resources of concern. The Mercalli Intensity Scale is a measure of the type of damage or potential damage done to structures by an earthquake. An earthquake intensity of VII (Richter magnitude 5.0 to 5.9) would likely cause localized damage to fragile or at risk resources such as those in geologically unstable areas. An intensity level of XII (> magnitude 7.0) can distort line of sight and ground levels resulting in extreme impacts on natural resource, destabilization of ecological integrity (increasing the potential for landslides and surface erosion), and destruction of infrastructure and resources. An earthquake event affecting less than 3,000 km^2 (Figure 1.7) could still be significant to the area affected; but would not likely be of sufficient intensity to initiate ecosystem level changes or to affect ecosystem structure or integrity.

In the late 70's and early 80's, the study of the transformation of natural ecosystems by human activities was called "Stress Ecology" (*c.f.* Rapport *et al.*, 1985). Differentiation of ecosystem stress and impacts resulting from human activities were recognized as significant sources of ecosystem change impacting not only ecosystem function and integrity but also impacting the services provided by ecosystems that are of direct benefit to human dominated or urbanized communities. Ecosystem dysfunction was thought to be detectible by screening (from a medical perspective) a group of common ecosystem components or processes (*c.f.* Rapport *et al.*, 1985). Additionally, Rapport *et al.* (1985) identified several pathways of human disturbance that might be monitored to assess ecosystem dysfunction. These include:

1) *Changes in nutrient cycling* – Downward leaching and lateral transport of nutrients is widespread in disturbed terrestrial and aquatic ecosystems.
2) *Changes in primary productivity* – Changes in primary productivity often follow changes in nutrient availability.
3) *Changes in species diversity* – One of the most widespread signs of ecosystem response to distress is a reduction in species diversity.
4) *Retrogression* – Exotics (alien) or locally rare species displace abundant native species. These invaders are opportunistic in character and tend to be short-lived.
5) *Changes in distribution of species* – A general effect of stress on both terrestrial and aquatic ecosystems is a reduction in the average size of dominant biota.
6) *Other signs of distress* – Less well documented symptoms of ecosystem distress include alterations in disease incidence and changes in amplitude of fluctuations in component populations.

While human history within Mediterranean-type ecosystems globally is quite varied in duration and intensity, Mediterranean-type ecosystems are among the most disturbed ecosystems in the world (*cf*. Samways, 1998). Primary disturbances resulting from human habitation include changes in fire frequency and intensity, grazing of introduced species, urbanization, agricultural expansion, deforestation, and the introduction of alien species (Rundel, 1998b).

Impacts from European cultures in non-Mediterranean Basin Mediterranean-type ecosystems have accelerated as populations have grown and urbanization and industrialization have increased. The convergence of climate and ecosystem structure among the widely distributed Mediterranean-type ecosystems has provided opportunities for classic comparative ecosystem studies (Rundel, 1998b). These studies have examined aspects of ecological function, fire ecology, nutrients, resilience, plant stress response, plant-animal interactions, biogeography, water relations, biodiversity, and global change (Rundel, 1998b & see Appendix III).

The resistance of biotic resources to stress and the ability to rebound or recover from a stress or disturbance event (self-organization or self-integration) are also considered to be significant attributes of ecosystems that can be measured and observed. These properties are important in determining threshold values for management decisions and are termed, respectively, ecosystem inertia and ecosystem resilience (Westman, 1986). In general, Westman (1986) defines resilience as “The pace, manner, and degree of recovery of ecosystems properties following natural or human disturbance.” whereas inertia is “The resistance of an ecosystem to change when stressed.” Stress and disturbance take on very specific definitions in relation to resilience and inertia. Stress by Westman’s definition refers to growth limitation on flora (generally) resulting from changes in nominal conditions related to habitat features such as water, light, nutrient availability, and suboptimal temperatures. Disturbance on the other hand refers to biomass destroying events such as frost, herbivory, and fire (Westman, 1986). Stress and disturbance can be either natural events or human induced. Perturbation is often used to describe the most extreme disturbance events (Dell *et al.*, 1986).

Ecosystem resilience can be a somewhat problematic to quantify as individual species, both plant and animal, have their own unique limits to resistance (inertia) and resilience in response to stress and their own unique pattern of recovery after disturbance or perturbation (Grubb & Hopkins, 1986; *c.f.* Westman, 1986). Additionally, stable limit cycles or lags in the expresion of species population characteristics may mask the effects of a given stress or disturbance event or depending upon the timing of the stress can either ameliorate or exacerbate the effects (*c.f.* Westman, 1986). Efforts to develop predictive indices of community response to stress or disturbance in Mediterranean-type ecosystems are best focused on an autecological rather than a synecological approach. “Identifying those features of species in a community which make them vulnerable to an applied stress or particularly well-adapted to resisting or recovering from the stress" can often provide early warning on the eventual effects of a particular stress or disturbance at the community level (Westman, 1986). Such species are often called focal species.

Ecosystem integrity may be variously defined (Woodley *et al.,* 1993; Noon, 2003), but in the context of natural ecosystems that are or may be significantly impacted by human activities ecosystem integrity must include some realization that ecosystems driven by combined natural and human drivers or stressors must be managed to maintain a self-organizing or self-correcting capacity that operates within an end condition that is a combination of both natural process and cultural (human) influence. While this condition is not pristine it none the less can be considered "good" and a desirable state to maintain (Regier, 1993). This is especially true for the two highly urbanized parks of the Mediterranean Coast Network. In an environment that incorporates natural open space with one of the largest and most densely populated regions of the United States a realization that any acceptable end state for ecosystem integrity must include a significant human element is essential to successful management of the resources in that system. Such an ecosystem, one that is significantly influenced by natural processes yet is permanently impacted by human activities, can be very dynamic and as a function of fluctuating stresses and perturbations can alternate between states of higher or lower levels of self-integration. The task of resource conservation managers is to limit movement of ecosystems towards high or low states of self-integration that once reached could leave an ecosystem perilously close to a threshold condition that if crossed could result in a new stable and undesirable state of integrity, or as put by Regier (1993) a state of ecosystem disintegration.

The Center for Biological Biodiversity (CBB) a consortium of non-government conservation organizations in southern California has published an alternative management strategy for the four national forests in southern California. Among their strategies for resource management and protection they have identified several species of animals for designation as focal species that can serve as indicators of ecosystem integrity. Focal species can be common barometers of the collective health of ecosystems. Monitoring of these species can provide information representative of the ecological integrity of targeted ecosystems, and can provide information to help managers protect natural habitats and processes. Various focal species categories currently being used include umbrella, keystone, flagship, habitat quality indicator, wilderness quality indicator, and prey species. Categories of focal species of significance in the Mediterranean Coast Network and the definitions of these categories are presented in table 1.2.

CBB (2002) has identified "umbrella and habitat indicator focal species whose viability or recovery is tied to the following conservation goals: native species recovery, stream and riparian recovery, restoration of natural processes, protection and restoration of landscape connectivity, elimination or control of exotic species, and protection and restoration of natural habitats." Specific focal species identified by CBB that occur in MEDN parks, their focal species designation, and their justifications for selection are presented in table 1.3.

1.9.6 Water Quality Issues in Network Parks

Park units of the Mediterranean Coast Network may be included in or are influenced by at least five U.S.G.S. defined watersheds (Hydrologic Unit Code – HUC): Calleguas (HUC 18070103), San Diego (HUC 18070304), Santa Barbara Channel Islands (HUC 18060014), San Pedro Channel Islands (18070107) and Santa Monica Bay (HUC 18070104) (Figure 1.8). Over 120 streams from these watersheds are listed as 303d impaired water bodies by the State of California. To date no information has been found that indicates any waters within these watersheds are listed as Outstanding Natural Resource Waters. The California 1998 305(b) report indicates that 19% or less of all water bodies in the Santa Monica Mountains meet all designated uses, there are insufficient data to categorize the water bodies of the Channel Islands, and even though San Diego Bay is considered to be the second most polluted bay in the United States, 80% or more of the water bodies in the San Diego Basin meet all uses.

Table 1.2 Focal Species categories and definitions for species whose general condition may be considered an indication of overall ecosystem integrity for the reasons stated. References cited in table were not consulted directly but pulled from CBB, 2002.

Focal Species Categories	Focal Species Definitions
Umbrella species	Wide-ranging species, such as large carnivores. Because of their need for expansive wildlands, protecting enough habitat for a viable population benefits other species with less extensive spatial requirements (Noss and Cooperrider, 1994, Noss *et al*., 1996, Meffe and Carroll, 1997).
Keystone species	Species whose influence on community structure and function is out of proportion to their abundance (Paine, 1980, Terborgh, 1988, Mills *et al*. 1993 in Miller *et al*., 1998). Large carnivores are often keystone species (Terborgh, 1988), because maintaining viable populations of these species will provide opportunities to maintain or restore ecosystem processes (Miller *et al*., 1994).
Flagship species	Charismatic creatures that appeal to a wide range of people. Flagship species can be utilized in education and outreach campaigns to raise the awareness level and draw attention to conservation objectives (Noss and Cooperrider, 1994, Meffe and Carroll, 1997).

While each of the three parks of the network includes or is adjacent to significant marine waters, no marine waters lie within the boundaries of the Santa Monica Mountains National Recreation Area. This park is within the boundaries of the Santa Monica Bay Estuary and several significant coastal lagoons are within the boundaries of the recreation area. Channel Islands National Park lies within the Channel Islands Marine Sanctuary and nearly half of park lands are submerged. Coastal resources are a significant component of management priorities at Cabrillo National Monument. Of the 116 hectares of lands owned and administered by Cabrillo, 52 hectares are marine intertidal. Additionally, 2.25 km of coastline are managed by Cabrillo. Cabrillo also manages coastal resources 275 meters out from the shoreline at mean lower low water on the western side of Point Loma.

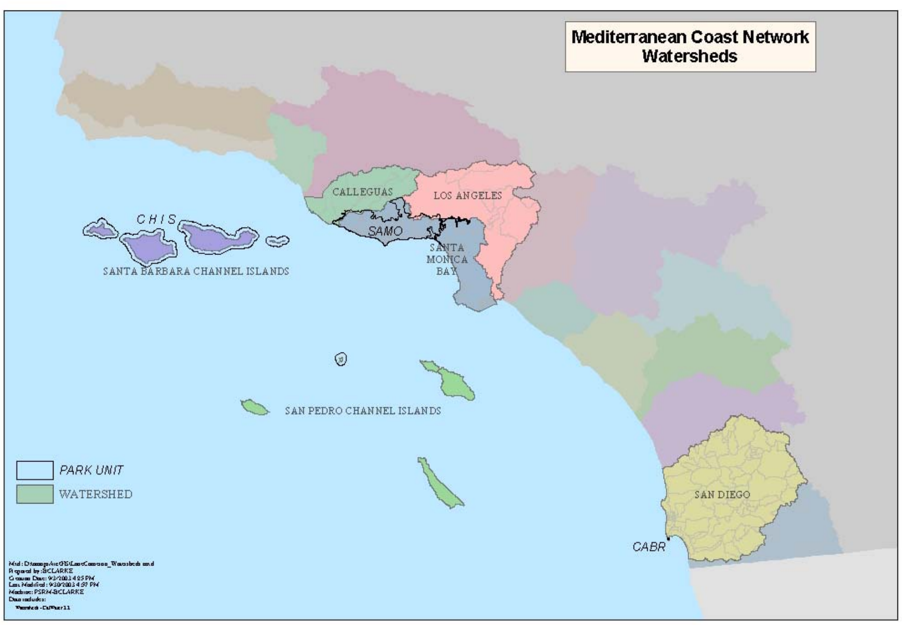

Figure 1.8 Major watersheds encompassing the parks of the Mediterranean Coast Network.

Table 1.3 Possible focal species for the Mediterranean Coast Network as identified by Center for Biological Biodiversity (2002). The category of focal species and the justification for their selection is given.

MEDN Focal Species	Umbrella	Keystone	Flagship	Habitat Quality	Prey Species	Justification for Selection
Mountain lion (*Felis concolor*)	✓	✓	✓			The largest remaining carnivore in the ecoregion; its primary requirements are large core habitat areas, abundant prey, and habitat connectivity among subpopulations. The mountain lion is an umbrella species because of its extensive spatial requirements, a wilderness quality indicator because it requires extensive wildlands to thrive, a keystone species because of its role in top-down regulation, and a flagship species because they are important symbols of wildness to a diverse public
Mule deer (*Odocoileus hemionus*)			✓	✓	✓	The primary prey of mountain lion and the most important big game animal in southern California. This habitat quality indicator is dependent on meadows and riparian habitat for fawning areas and moves seasonally. In addition, since mule deer are sensitive to ecological process such as fire, its status can reflect the effects of different fire management strategies
Southern steelhead trout (*Oncorhynchus mykiss*)	✓		✓	✓		Have specialized habitat requirements and move seasonally between different elevations. They are also dependent on fire to shape their habitat chosen as an aquatic habitat quality indicator, umbrella, and flagship species. It rates as an aquatic habitat quality indicator because it requires structurally complex riparian habitat with stream shading to regulate water temperatures. It is also sensitive to water quality changes. This species is dependent on all reaches of riparian systems, at different life stages, from the ocean to the headwaters, for spawning and rearing. The steelhead is also considered an umbrella species because its presence is an indication of overall watershed integrity, and a flagship species because of its popularity among anglers
Least Bell's vireo (*Vireo bellii pusillus*)	✓		✓	✓		Chosen as a habitat quality indicator for structurally complex riparian communities. This neotropical migrant requires habitat connectivity to South America, via high-quality riparian habitat. It is sensitive to disturbance and habitat degradation and therefore useful in monitoring activities and uses on the Forests. It was identified as an umbrella species because protection and restoration of adequate riparian woodlands for a viable population of vireos throughout southern California will protect habitat for other riparian-dependent species. It was also identified as a flagship species because of its popularity among birders
Arboreal salamander (*Aneides lugubris*)				✓		Chosen as a habitat quality indicator for mature oak woodlands; downed wood and leaf litter are essential habitat components. Because this species requires oak woodlands, which have a patchy distribution, it is considered a resource-limited species
Bell's sage sparrow (*Amphispiza belli belli*)				✓		Identified as a habitat quality indicator for coastal sage scrub and lower montane chaparral habitats; the species prefers habitat mosaics of varying age-classes
Southwestern pond Turtle (*Clemmys Marmorata pallida*)				✓		Chosen as a habitat quality indicator for aquatic ecosystems and surrounding upland habitat because they are negatively impacted by predatory invasive species, alteration of aquatic and surrounding terrestrial habitats, and water pollution – impacts that are also causing the decline of numerous other aquatic wildlife species

A survey of all freshwater monitoring efforts occurring within network parks and marine water monitoring within one mile of the coasts of network parks was conducted. The focus was on identifying all agencies or organizations conducting water quality monitoring and to gather information about the water quality parameters being monitored, monitoring frequency, sample collection methods, data analysis procedures, and data storage procedures. A draft copy of the report from this effort is included in Appendix IV.

1.9.6.1 Cabrillo National Monument

Cabrillo National Monument is situated on the southern tip of Point Loma. To the east the park overlooks the mouth of San Diego Bay and the City of San Diego, and to the west it has an unobstructed view of the Pacific Ocean. San Diego Bay waters effectively wash the eastern flank of the park with each tidal cycle. Degraded benthic communities, sediment toxicity, dissolved copper, and coliform and enterococci bacterial contamination have resulted in 303d listing for the San Diego Bay Shoreline Point Loma Hydrological Area at the U.S. Navy Submarine Base, the Shelter Island Yacht Basin, at Kellogg Street, and at the Shelter Island Shoreline Park. All these locations are within a few kilometers of the Cabrillo National Monument eastern shoreline and the intertidal resources around Point Loma on the western side of the peninsula.

On the western side of Point Loma is the City of San Diego E.W. Blom Metropolitan Waster Water Treatment Plant. This is the primary waste water treatment facility for the City of San Diego and surrounding communities. Waste water is brought from a nearly 1200 km^2 area to this 16 hectare site which processes 720×10^6 L of waste water per day and deposits some 11,000 metric tons of suspended solids per year into the waters off Point Loma. National Pollutant Discharge Elimination System permitting for the Blom Waste Water Treatment Plant requires regular and extensive monitoring of offshore marine waters. These monitoring results are public information and readily available for review.

While there are several drainage channels within the management area for Cabrillo National Monument these contain flowing water for only a few hours after significant rainfall events. The geomorphology of Point Loma does not support any truly ephemeral or perennial streams. There is an historic record of a pond on Point Loma but it was filled in many years ago. Because of its proximity to the Pacific Ocean precipitation in the form of fog drip is quite common and a significant amount of ground water is present as indicated by several freshwater seeps along the heavily eroded coastline of Point Loma and within the management area of the monument.

1.9.6.2 Channel Islands National Park

Surface water resources in Channel Islands National Park include the Pacific Ocean, Santa Barbara Channel, Santa Cruz Channel, Anacapa Passage, San Miguel Passage, and numerous bays and coves. There are several perennial creeks on San Miguel, Santa Rosa, and Santa Cruz Islands and many springs throughout the park. Very little if any marine water quality data exist for the park. From 1983 through 1994 some 2,000 observations for 14 separate parameters were collected from 15 freshwater monitoring stations located within the park's boundaries. Eleven stations were located on Santa Rosa Island and four stations on Santa Cruz Island. Eight of these stations were monitored only once or if monitored several times it was done in a single calendar year. Seven stations on Santa Rosa Island were sampled in more than one year.

Beginning in 1975, Areas of Special Biological Significance (ASBS) were designated by the State (California) Water Resources Control Board as those areas requiring protection of species or biological communities to the extent that alteration of natural water quality is undesirable. The waters surrounding San Miguel, Santa Rosa, and Santa Cruz Islands to a distance of one nautical mile offshore or to the 300-foot isobath, whichever is the greatest distance, and the waters surrounding Santa Barbara Island and Anacapa Island have been listed as ASBS No. 17 and ASBS No. 22 respectively. As of January 2003, Areas of Special Biological Significance were renamed as State Water Quality Protection Areas (SWQPAs). Additionally the California Coastal Commission's Nonpoint Source Pollution Control Program has designated selected locations as Critical Coastal Areas (CCAs). CCAs are defined as areas where water quality is threatened by new or expanding land uses. Because of their listing as State Water Quality Protected Areas San Miguel, Santa Rosa, and Santa Cruz Islands are designated as CCA – 55 and Santa Barbara Island and Anacapa Island as CCA – 56.

Since 1993, Channel Islands National Park has been monitoring water quality at a number of locations within the Lobo, Water, and Quemada drainages on Santa Rosa Island. Cattle were removed from Santa Rosa Island in 1998 and substantial improvement in water quality and riparian vegetation has been observed. Water quality in these drainages reflects the lack of a functioning riparian community and the impacts of past cattle grazing. With no riparian vegetation to slow water flow, stream flows peaked dramatically during storm events, and summer flows were lower than what would be expected if there was a normal riparian system associated with these streams, this lack of riparian vegetation also led to increased sediment transport during storm events. Total suspended sediment levels during storm events have been recorded at thousands of times greater than baseline levels. The lack of riparian vegetation to shade the streams also led to higher than normal water temperatures.

Results of water quality testing indicate that many of the streams on Santa Rosa Island are alkaline. This alkalinity is most likely unrelated to past or present grazing activity. Diurnal differences in dissolved oxygen concentrations with super saturation of stream waters during the day suggest impacts from algae in the streams. Coliform bacteria levels in the streams reflect pollution from cattle feces. Recent monitoring has shown substantial improvement is all of these parameters.

1.9.6.3 Santa Monica Mountains

The aquatic resources of the Santa Monica Mountains are very diverse. Dozens of north-south canyons parallel each other throughout the mountains. Each of these has an intermittent or perennial stream, with an associated riparian vegetation corridor, and there are numerous east-west trending drainages coming down the slopes of these canyons. Across the Santa Monica Mountains Zone (a region that extends beyond the recreation area boundary to include all watersheds that are within or partly within the recreation area) there are a total of 828 stream segments, including 179 major streams with 49 coastal outlets.

The largest watershed within the recreation area is the 270 km^2 Malibu Creek watershed which incorporates several major drainage basins (Medea Creek, Triunfo Creek, Cold Creek, and Malibu Creek; and Sleeper, Las Virgenes, and Potrero Valleys). Conversely, the smallest stream courses in the Santa Monica Mountains are in isolated drainages which comprise 17 percent of all streams in the Santa Monica Mountains Zone (figure 1.9).

A wide variety of wildlife and localized plant communities can be found associated with the streams and aquatic resources of the Santa Monica Mountains. These include one of the southernmost U.S. runs of the Ecologically Significant Unit (U.S. Fish and Wildlife designation) steelhead trout (*Oncorhynchus mykiss*). A diverse array of aquatic insects and unique populations of big leaf maples (*Acer macrophyllum*), cottonwoods (*Populus* sp.) and alder (*Alnus* sp.) are also associated with streams within the mountains. The arroyo chub (*Gila orcutti*) is found in Malibu Creek and the endangered tidewater goby (*Eucyclogobius newberryi*) was recently reintroduced (1991) to Malibu Lagoon. In creeks that feed from the developed recreational/water supply lakes in the mountains, a variety of alien fauna have been introduced, some of which significantly impact sensitive native communities.

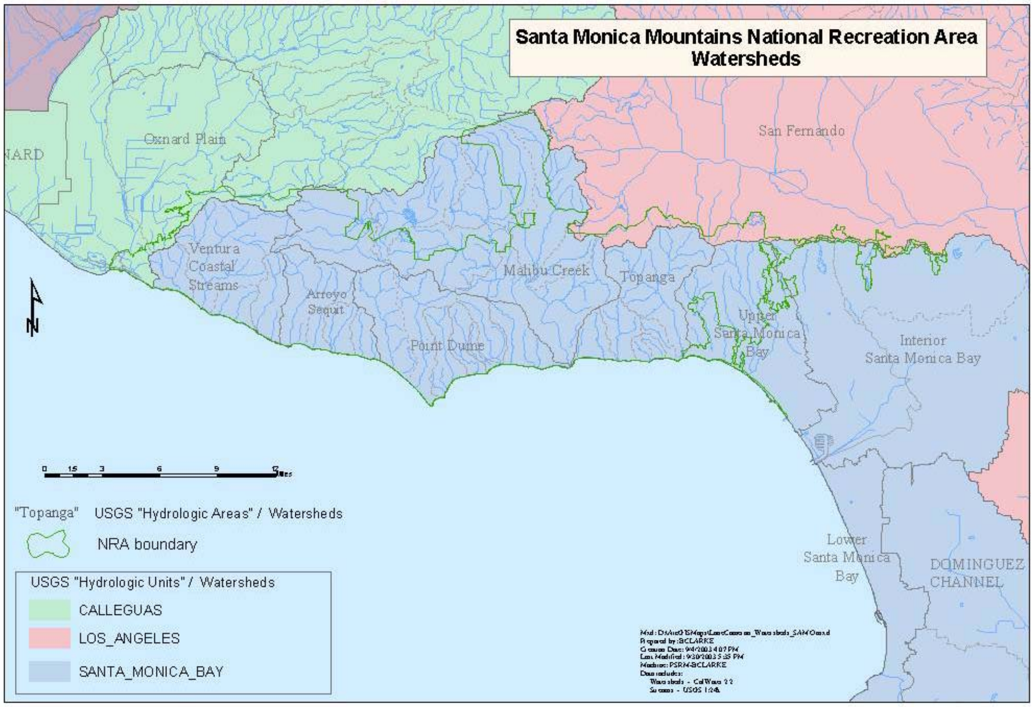

Figure 1.9 Administrative Watersheds of the Santa Monica Mountains National Recreation Area.

Runoff originating from developed areas (e.g., roads, parking lots, and residential and commercial development) has placed significant pressures on existing fresh water resources by increasing stream flow and flow duration. Runoff from developed areas contains elevated levels of nutrients (such as phosphorous and nitrogen), pathogens, toxicants (e.g., heavy metals), and litter and trash. It is critical to identify and monitor the consequences of these impacts on the condition and quality of water resources in the Santa Monica Mountains. Within the Santa Monica Mountains from Pt. Mugu to Santa Monica Canyon there are 9 streams, 4 lakes, and 1 lagoon listed as impaired on the state's 303d list (Table 1.4).

Numerous ongoing water quality monitoring efforts are being conducted in the mountains. Often they are independent projects with very little interagency coordination. For example, in the Malibu Creek watershed alone (Review of Monitoring and Response Protocol for the Malibu Creek Watershed, 1994) there are 42 surface water and sediment monitoring groups and over 70 ground water monitoring wells. Some samples are analyzed for a complete suite of chemical constituents ranging from conventional pollutants to organic chemicals, pesticides, bacteria and viruses while others have a more limited scope of analysis.

A State of California initiative that promises to be of great value to the Santa Monica Mountains is the Surface-Water Ambient Monitoring Program (SWAMP). SWAMP is a statewide monitoring effort designed to assess the conditions of surface waters throughout the state of California. The program is administered by State (California) Water Resources Control Board. Responsibility for implementation of monitoring activities resides with the nine Regional Water Quality Control Boards (RWQCBs) that have jurisdiction over their specific geographical areas of the state. Monitoring is conducted in SWAMP through the Department of Fish and Game and U.S. Geological Survey master contracts and local RWQCBs monitoring contracts.

SWAMP also hopes to capture monitoring information collected under other State and Regional Board Programs such as the State's TMDL (Total Maximum Daily Load), Nonpoint Source, and Watershed

Project Support programs. SWAMP does not conduct effluent or discharge monitoring which is covered under National Pollutant Discharge Elimination System permits and Waste Discharge Requirements.

Table 1.4 303d listed water bodies in the Santa Monica Mountains National Recreation Area that are include in the Santa Monica Bay Watershed and their reason for listing.

Water Body Name	Impairment:
Lake Lindero	Selenium, Algae, Chloride, Eutrophication, Odor, Specific Conductance, Trash
Lake Sherwood	Mercury, Algae, Ammonia, Eutrophication, Organic Enrichment/Low Dissolved Oxygen
Westlake Lake	Chlordane, Algae, Ammonia, Eutrophication, Organic Enrichment/Low Dissolved Oxygen, Copper, Lead
Malibu Lake	Chlordane, Algae, PCBs, Eutrophication, Organic Enrichment/Low Dissolved Oxygen, Copper
Malibu Lagoon	Benthic Impacts, Enteric Viruses, High Coliform, Eutrophication, Shellfish Harvesting Advisory, Swimming Restriction
Malibu Creek	Fish Barriers, Algae, High Coliform, Scum/Foam, Trash
Las Virgenes Creek	Selenium, Algae, High Coliform, Organic Enrichment/Low Dissolved Oxygen
Lindero Creek Reach No. 1	Selenium, Algae, High Coliform, Scum/Foam, Trash
Lindero Creek Reach No. 2	Selenium, Algae, High Coliform, Scum/Foam, Trash
Medea Creek Reach No. 1 (Lake to Confluence with Lindero Creek)	Selenium, Algae, High Coliform, Trash
Medea Creek Reach No.1 (Above Confluence with Lindero Creek)	Selenium, Algae, High Coliform, Trash
Palo Comado Creek	High Coliform
Santa Monica Canyon	Lead, High Coliform
Stokes Creek	High Coliform
Topanga Canyon Creek	Lead
Triunfo Canyon Creek Reach No. 1	Lead, Mercury
Triunfo Canyon Creek Reach No. 2	Lead, Mercury

The SWAMP program will monitor some 33 streams within the Santa Monica Mountains once in the next two years. If funding continues, the SWAMP program will repeat this monitoring every two years. A significant opportunity exists for the network to partner with the SWAMP program in either adding sampling locations or to conduct repeated monitoring in selected streams in the off-year for a particular stream. Target contaminates identified for testing under the SWAMP program include: Trace Organic Chemistry, Trace Metal Chemistry, Conventional Water Chemistry, Bacteriology and Pathology, Biological Assessment, Toxicity Testing, and Fresh Water Origin.

SWAMP sampling also includes sampling required by the Toxic Substance Monitoring Program (TSMP) and the mussel watch program. TSMP is a state wide initiative to detect toxic substances in fresh, estuarine, and marine waters of the state through analysis of the tissues from fish and other aquatic life. Detection and analysis of toxic substances in bays, harbors, and estuaries of the state are monitored through the State Mussel Watch Program, wherein tissues are analyzed from transplanted and resident clams and mussels. This program usually targets areas with known or suspected impaired water quality and is not intended to be an overall water quality assessment.

1.9.6.4 Summary

It is more than evident that because of the urban nature of the Santa Monica Mountains and known impairments to many local waterways water quality concerns within the mountains have been a high priority for local conservation groups, and regional, state and federal agencies for many years. Much more so than in any of the other two parks of the network. In Cabrillo National Monument, with virtually no freshwater resources and notwithstanding it's proximity to the City of San Diego, the U.S. Navy's facilities on Point Loma, and the Blom Waste Water Treatment Plant, establishing a significant water quality monitoring program has been until recently a low priority to park managers. Additionally, at Channel Islands National Park because of the paucity of potential impacts to marine and fresh water resources resource managers have generally focused their monitoring efforts on resources other than water quality.

1.9.7 Air Quality in MEDN Network Parks

The quality of the air in the parks of the Mediterranean Coast Network, situated as they are on the western margin or off shore of the coast of southern California, can be affected by human caused air pollution from the Los Angeles basin and the San Diego metropolitan area. This situation is ameliorated somewhat by the prevailing westerly winds that continually push and concentrate polluted air to the east away from network parks. Still the risk of foliar damage to vegetation from ozone in the parks of the Mediterranean Coast Network is quite high. Nutrient accumulation from atmospheric deposition seems to be of minor consequence to the parks of the Mediterranean Coast Network. None of the parks of the Mediterranean Coast Network are rated as Class I air quality parks and the Prevention of Significant Deterioration clause of the 1997 amendment to the clean air act does not apply. Santa Monica Mountains NRA and Channel Islands NP are Class II floor areas. These are national park units designated after 1997 and that are greater than 4,050 ha in size. Several air quality monitoring agencies have jurisdiction over air quality issues in the parks of the MEDN. These include the California Air Resource Board, the South Coast Air Quality Management District, the Ventura County Air Pollution Control District, and the County of San Diego Air Pollution Control District. With the exception of a single ozone monitoring station on Santa Cruz Island and a visibility monitoring station in Cabrillo NM air quality monitoring stations for the region are all located outside of park boundaries. Table 1.5 lists specific air quality monitoring questions suggested by participants at workshops and in discussions with natural resource managers at network parks. In addition to these monitoring questions, the specific ecosystem resource considered to be at risk and the metrics suggested for monitoring specific resources-at-risk are given.

Table 1.5 Air quality related monitoring questions for Mediterranean Coast Network parks, resources-at-risk, and suggested metrics for answering the monitoring question and protecting the resource-at-risk.

Monitoring Question	Resource-At-Risk	Suggested Measures
1. How are scenic landscapes changing over time? 2. What are the status and trends in Ambient Air Quality?	Visibility	1. Atmospheric Metal Concentrations (Hg, Pb, Cd, Co, Zn, Ni) 2. Dioxin Concentrations 3. Visibility Monitoring (Clarity) Change in visibility deciviews 4. Volatile Organic Chemical Concentrations (Benzene, Toluene, Methylene Chloride)
1. What are the status and trends in Ambient Air Quality? 2. What are the status and trends in Lichen population and community dynamics?	Plant Community Distributions	1. Continuous Sulfur (SO_2) Dioxide Concentrations 2. Lichen Abundance, Cover, Tissue Analysis, and Diversity 3. Morphological Changes 4. Nitrogen & Sulfur Deposition (Accumulation Rate in Soil) 5. Wet Deposition Chemistry (pH, NO_3-, SO_4=) 6. 0_3 concentrations Sum 06 and W126.

A recent ozone injury risk assessment prepared by the NPS Air Resources Division for the Channel Islands and the Santa Monica Mountains is summarized below. Ambient concentrations of ozone are reported as Sum06, W126, N60, N80, and N100 exposure indices. The Sum06 index is a running 90-day maximum sum of the 0800 to 2000 hourly ozone concentrations ≥ 0.06 ppm-hr. The W126 exposure index is a weighted sum of all hourly ozone concentrations, where each hourly measure is weighted giving higher weights to the higher hourly concentration values. N60, 80, and 100 are the number of hourly average ozone concentrations above 60, 80, or 100 ppb. Sum06 ozone exposures of 8 – 12 ppm-hr are known to cause foliar injury to plants. W126 measures of 5.9 to 66.6 ppm-hr and N100 measures of 6 to 135 are also injurious to plants depending upon their sensitivity.

The uptake of ambient ozone by plants is highly dependent upon the environmental conditions under which the exposure takes place. Soil moisture level is an important environmental variable controlling the process. Low soil moisture reduces the likelihood of ozone uptake thereby reducing the risk from exposure. The Palmer Z soil moisture index represents the short-term departure of soil moisture from the monthly average for a given site. Soil moisture data were not available for either the Channel Islands or the Santa Monica Mountains, and without site-specific data, ozone/soil moisture relationships can only be estimated. In lieu of site-specific data, the Palmer Z Index data from locations nearby the two parks were used to estimate soil moisture for evaluating ozone risk in Channel Islands NP and Santa Monica Mountains NRA. However, site-specific criteria such as aspect, elevation, and soil type can alter soil moisture conditions such that they may depart significantly from those determined for the region.

1.9.7.1 Cabrillo National Monument

While visibility data are being collected on a regular basis in Cabrillo NM no analysis of these data are being done at the present time. Specific air quality issues and risk of air quality caused degradation of the resources at Point Loma are currently under evaluation by the Air Resources Division of the National Park Service. Park natural resource managers and workshop participants have identified air chemistry as a significant issue in Cabrillo NM and the other parks of the network. Determining the status and trends in Ambient Air Quality was identified as a priority consideration for the network monitoring program. Visibility, lichens, and plant communities were identified as the at-risk resources or ecosystems attributes that could be impacted by degraded air quality.

1.9.7.2 Channel Islands National Park

The National Park Services Air Resources Division recently identified four species of plants common to the Channel Islands, mugwort (*Artemisia douglasiana*), Monterey pine (*Pinus radiata*), black locust (*Robina pseudoacacia*), and blue elderberry (*Sambucus mexicana*), as sensitive to and potentially at risk from ambient ozone levels in the islands. The Sum06 index in Channel Islands NP is below the threshold for injury (Table 1.6). While the W126 accumulative value is above the threshold, the N100 count is below the required number and thus the criteria for injury are not satisfied. The Sum06 and W126 indices are both below the levels considered necessary for injury to vegetation. N-values for the site show no concentrations of 100 ppb or greater and relatively few greater than 80 ppb. These observed levels of exposure are unlikely to cause injury to vegetation. High concentrations of ozone do not appear to be consistently associated with low levels of soil moisture. In 1998 when ozone concentrations were high, soil moisture levels were also high. In contrast, in 1996 when ozone was high, soil moisture was that of a mild drought and likely had a minor effect on reducing the uptake of ozone. Several months of mild and moderate drought occurred in three of the five years assessed. Generally the low levels of ozone exposure and relatively dry soil moisture conditions at Channel Islands National Park renders the risk of foliar ozone injury to plants quite low.

1.9.7.3 Santa Monica Mountains National Recreation Area

Three species of plants common to the Santa Monica Mountains, tree-of-heaven (*Ailanthus altissima*), mugwort (*Artemisia douglasiana*), and Gooding's willow (*Salix gooddingii*)**;** have been identified as sensitive and at risk to ambient ozone levels in the mountains. The Sum06 and W126 indices both exceed the levels considered critical for injury to vegetation (Table 1.7). The N-values for concentrations of 60, 80, and 100 ppb are all elevated and show there are a significant number of hours during which plants are exposed to levels of ozone likely to produce foliar injury. Soil moisture levels during the 90-day Sum06 accumulation periods show no association with the levels of ozone. In two high ozone years (1995 & 1996), soil moisture was normal in 1995 while in 1996 there was mild drought in all three summer months. In the lowest ozone year, 1999, soil moisture conditions showed mild to moderate drought in all three months. Relationships between the W126 levels of ozone and soil moisture conditions are mixed. Soil moisture levels associated with the seasonal W126 index show high exposure in 1996 were associated with a six-month period of mild drought that would reduce the uptake of ozone, while in 1995 high exposure was associated with moisture conditions favoring the uptake of ozone. In 1999, lower levels of ozone were associated with mild to moderate levels of drought in five of the seven months. There do not appear to be any consistent relationships between levels of ozone exposure and soil moisture. However, in three of the five years assessed, mild to moderate drought stress occurred in at least six of the seven months of indexing; in the other two years one of the months had mild drought and the remaining months were normal. This pattern suggests that major portions of the growing seasons at the site are either favorable or unfavorable for the uptake of ozone with respect to soil moisture conditions.

Table 1.6 Ozone concentration data from Channel Islands NP as compiled by the NPS Air Resources Division.

Ozone Air Quality Data for Channel Islands National Park				
	1996	1997	1998	1999
Sum06	5	4	5	3
W126	17.9	11.4	15.8	13.9
N60	216	95	145	123
N80	18	2	4	4
N100	0	0	0	0

Table 1.7 Ozone concentration data from the Santa Monica Mountains NRA as compiled by the NPS Air Resources Division.

Ozone Air Quality Data for Santa Monica Mountains NRA					
	1995	1996	1997	1998	1999
Sum06	35	33	24	24	18
W126	28.0	32.7	36.7	48.0	49.0
N60	739	743	607	506	470
N80	272	251	154	146	97
N100	93	74	30	45	14

1.10 Current & Historic Monitoring in Network Parks

While there is a significant overlap in the resource elements presently being monitored by all three parks (Table 1.8), these monitoring priorities have generally developed independently. As a prototype monitoring Park, Channel Islands National Park has a well-developed monitoring program that began nearly twenty years ago. Cabrillo National Monument and Santa Monica Mountains National Recreation Area, supported by various National Park Service and non-National Park Service funding sources and by partnering with universities and other agencies, have initiated inventory and monitoring on a smaller scale.

1.10.1 Cabrillo Monitoring

Since 1990, the condition of tide pools adjacent to Cabrillo National Monument has been monitored almost exclusively through the services of volunteers. Significant declines in several indicator species led the park to restrict public access to ⅓ of the beach area of the tide pools. The public, because of the information gained through the monitoring program, has supported this otherwise controversial decision.

Park managers have worked with staff from other NPS units and U.S.G.S. as well as academic partners to develop and implement this and other monitoring and natural resource programs.

Table 1.8 Ongoing and planned vital signs monitoring within the Mediterranean Coast Network.

Resource	Park Status		
Marine	CABR	CHIS	SAMO
Tidepools	X	X	
Kelp Forest		X	
Pinnipeds		X[1]	
Fisheries Harvest		P	
Fish	F		
Plants			
Vegetation Communities	X	X	F
Vegetation Populations (alien exotics)	F	P	F
Vegetation Populations (sensitive/rare species)	F	P	F
Animals			
Small Mammals	F	P	F
Carnivores	F	P	X
Herpetofauna	X[2]	P	X[2]
Bats	F	P	F
Breeding Birds	F	X	F
Migratory Birds	F		
Raptors			F
Invertebrates	F	P	F
Salmonids			F
Streams (aquatic vertebrates and invertebrates)			X[3]
Physical and Social			
Air Quality	X[1]	X	X[1]
Habitat Fragmentation			X[4]
Visibility	X		
Geologic Hazards	F		F
Water Quality	F	P	X
Weather	X[1]	X	X[1]
Visitors	X	X	X
Sand Beaches		X	
Streams (basic water quality, stream conditions)			X[3]

X = Currently being monitored, and identified as a vital signs from workshops, monitoring plans, and/or resource management plans.
P = Monitoring protocols have been prepared, but not presently implemented. Target identified as a vital signs from workshops, monitoring plans, and/or resource management plans.
F = Future Monitoring. Target identified as a vital signs from workshops, monitoring plans, and/or resource management plans. Monitoring protocols are to be developed.
[1] Monitored conducted by a non-NPS Agency.
[2] Currently being inventoried will convert to monitoring in the future.
[3] The stream monitoring at Santa Monica Mountains is an integrated program examining aquatic vertebrates and invertebrates, basic water quality, and physical stream conditions (e.g. flow, pool depth).
[4] Carnivores currently monitored as indicators of habitat fragmentation.

Historically (through the 1930's), 19 species of reptiles and amphibians occurred on the Peninsula, of which 6 are now considered sensitive at the state or federal level. Herpetofauna inventories were initiated on Point Loma by Robert Fisher of the U.S.G.S. and Ted Case of the University of California at San Diego in August, 1995 utilizing 17 arrays of pitfall traps and drift fences. Data collection occurred from 1995 through 2001 to collect baseline data for the development of a long term monitoring plan (Fisher and Case, 2000). Long-term monitoring of reptiles and amphibians, terrestrial vegetation, and intertidal marine resources has been going on for up to as long as ten years on Point Loma (See Appendix II).

In the 1994 the U.S.G.S. began a program to inventory and monitor the plant communities on Point Loma. The primary focus of the initial stages of this program was to develop a plant species list (including vouchers) for the park. Other components of the program included:

- Contracting with San Diego State University to develop a written document of the historical record of vegetation at the monument ("Vegetation History of Cabrillo National Monument" 1995)
- Contracting with the Santa Barbara Museum of Natural History to conduct a lichen survey on Point Loma
- Preparing a video record interview with the outgoing Chief of Resource Management and Visitor Protection at Cabrillo NM to record vegetation changes he observed during his tenure in the park (1977 to 1994)

In conjunction with the development of the plant species list a long-term vegetation monitoring program was implemented to track changes in vegetation community diversity. This monitoring program generally parallels the protocols developed by the monitoring program at Channel Islands NP. The following habitats types are monitored within the park: coastal sage succulent scrub, southern maritime chaparral (C*eanothus verrucosus*), lemonade berry (*Rhus integrifolia*), cactus, and disturbed areas. Depending upon winter rainfall, sampling is conducted once every three to five years.

1.10.2 Channel Islands Monitoring

Identifying threats to park resources such as fishing, grazing, habitat fragmentation; air and water pollution; invasions by alien species; and loss of soil and vegetation have shaped the monitoring program at Channel Islands. Even before selection as an NPS prototype-monitoring park, Channel Islands had a relatively well-developed marine monitoring program in place. Park monitoring has directly led to many management actions including working to create harvest limits and fisheries closures for abalone and other marine species and alien species eradication efforts. The recent precipitous decline in the island fox population that was documented through their monitoring program led Channel Islands resource managers to quickly implement a multifaceted program to prevent extinction of this species.

With nearly half of the designated parklands of Channel Islands National Park being submerged, marine resources monitoring has been a significant aspect of the monitoring program at Channel Islands. Data derived from kelp forest monitoring have been instrumental in guiding coastal use regulations for the State of California and in providing a reliable data baseline for use in identifying changes in similar habitats associated with unprotected areas.

1.10.3 Santa Monica Mountains Monitoring

The unique nature of land ownership within the Santa Monica Mountains NRA has demanded a unique and aggressive resource management program focusing on maintaining, among other things, a high level of ecosystem integrity to ensure the perpetuation of park biodiversity. Fragmentation of vegetation habitats, habitat type conversion, and the introduction of exotic species thorough expanding residential development within the boundaries of the park are major threats to the viability of several populations of wildlife from amphibians and reptiles to mountain lions. In the last decade, Santa Monica Mountains NRA resource management programs have focused on gathering baseline information on park natural resources, developing long-term monitoring strategies for critical threatened resources, and in building relationships with local academic researchers and agency resource managers. More recently, with soft funding and funding from the Natural Resource Challenge, Santa Monica Mountains NRA has been able to implement some high-priority monitoring efforts consistent with the Vital Signs Monitoring program (see Table 1.8).

1.11 Identifying Monitoring Goals, Objectives & Vital Signs

The concept of identifying ecosystem, landscape, or park vital signs is an integral component of the monitoring program. Vital signs may be direct, surrogate, or derived measures of ecosystem processes or components that can reveal significant information about ecosystem or resource condition with the most efficient use of available manpower and monetary resources (cf. National Research Council, 2000). Vital signs may also be population or community characteristics of selected species or communities of species of concern to park managers or the public. Vital signs of ecosystem or natural resource health have been likened to the vital signs that a physician would monitor while treating a patient (*cf*. King, 1993). Natural resource managers are physicians to ecosystems and park resources; monitoring their health, treating dysfunction, and repairing damage (Davis, 1993).

The process of identifying monitoring goals, objectives and then vital signs of ecosystem health in the Mediterranean Coast Network began with a series of discussions with park resource managers, and a review of park general and resource management plans. Following this a series of workshops and discussion groups were organized to bring together subject matter experts from the National Park Service, state and federal agencies with stewardship over natural resources, and other interested parties and stakeholders to identify ecosystems drivers and stressors, and to review current management activities that would help determine the course of monitoring planning within the Mediterranean Coast Network. While this process has occurred independently for each of the three parks in the network, the experiences of Channel Islands National Park staff in establishing an ecosystem-monitoring program as a prototype monitoring park were especially helpful in inaugurating the network monitoring planning process.

1.11.1 Cabrillo National Monument

In January 2000, Cabrillo National Monument resource management staff began a process to identify ecosystem Vital Signs or critical ecosystem components or processes of the Point Loma ecosystem that if monitored could provide an indication the health of natural resources within and surrounding Cabrillo NM and the Point Loma Ecological Reserve. The first step in the process of developing vital signs was to hold a workshop to identify key natural resources in the area and to determine the survey efforts needed to assess these resources (Appendix V). Point Loma Ecological Reserve lands were included in the process because these lands are co-managed by the National Park Service (Cabrillo NM) and are important in the overall natural resource management strategy for the monument. This workshop was an initial pass at developing a list of vital signs to be further refined and then prioritized later.

The workshop brought together natural resource managers, scientists, and researchers from a wide variety of natural resource disciplines with research experience at Cabrillo National Monument or in similar ecosystems, and other subject matter experts or natural resource stakeholders with interests in Point Loma. During the workshop participants were introduced to the Vital Signs concept and the National Park Service natural resource management program. Topics presented included: “What are Vital Signs?” and “What is Point Loma?” (i.e., the components and elements of, and background information about the natural resource program at Cabrillo National Monument). Also provided was information on species of special concern and past inventory and monitoring projects at the monument. Workshop participants also toured the Point Loma Ecological Reserve. After the introductory sessions, participants were divided into the following topical work groups:

1. Marine Resources
2. Physical Resources
3. Terrestrial Vegetation
4. Terrestrial Wildlife

These work groups were asked to identify broad categories of resources or ecosystems processes within the framework of the group topic, and then to identify specific concerns and issues within these topical categories that would establish the foundation for identifying vital signs. The work groups then identified specific key natural resources or ecosystems processes and developed project statements to describe the natural resource of concern they had identified. These project statements were to serve as guides in developing inventory and monitoring needs for each of the natural resource issues identified. Project statements included:

1. Title (i.e., topic of concern)
2. Problem Statement – What is the problem/issue to be addressed?
3. Objectives

4. What do we know/have done already?
5. Descriptions of Recommended Activity
6. What are the Deliverables? Products?
7. Proposed Budget (e.g., number of personnel, contractor(s), equipment, travel, transportation, number of years, and all other components needed for the efforts).

A second vital signs workshop was held for Cabrillo National Monument in March of 2003 (Appendix VI). Some thirty invited participants reviewed a proposed conceptual model and participated in a computer based exercise to prioritize candidate vital signs. From these two workshops and through discussions with park resource managers 37 candidate vital signs were suggested for Cabrillo National Monument. Suggestions to improve the conceptual model were also made during this workshop.

1.11.1.1 January 2000 Workshop Results

Project statements for fourteen specific terrestrial categories and seven marine categories were developed. The terrestrial resources identified included (in alphabetical order):

1. Bats – Presence, distribution, and diversity changes from historic records
2. Birds – Population trends and habitat associations by group (e.g., breeders, raptors, migrants, shore birds, diving species)
3. Carnivore Communities – Long-term population trends
4. Herpetology (Reptiles and Amphibians) – Population trends and species richness monitoring
5. Small Mammals and Meso-Herbivores – Distribution and abundance
6. Small Mammals and Meso-Herbivores – Population trends
7. Small Mammal – Pacific Pocket Mouse presence
8. Physical Resources (Erosion) – Rates and impacts
9. Physical Resources (Fresh Water Resources) – Inventory
10. Physical Resources (Geological Resources) - Inventory
11. Terrestrial Invertebrates (Insects and Arthropods) – Diversity and densities
12. Terrestrial Invertebrates (Insects and Arthropods) – Diversity and abundance changes
13. Terrestrial Vegetation (Rare and Sensitive Species) – Plant and habitat distributions
14. Terrestrial Vegetation (Alien Species) – Plant distributions and population changes

Post-workshop discussions with park resource managers and network staff reduced this list to ten categories of resources for further consideration.

1. Monitoring of reptiles and amphibians
2. Long-term population trends in carnivore communities
3. Inventory of small mammals on Point Loma Ecological Reserve
4. Bat inventory of Point Loma area
5. Terrestrial invertebrate inventory and monitoring
6. Long-term bird population trends at Point Loma
7. Rare and endangered plant inventory and monitoring
8. Inventory and monitoring of noxious weed populations at Point Loma
9. Monitoring coastal and ocean-side erosion and other impacts on intertidal and near-shore marine communities
10. Physical resources – water resources

The marine resources group went much further in identifying critical resource or ecosystems components and following a habitat type and community monitoring approach identified the following specific topics for management action and monitoring consideration:

1. Conduct a performance analysis of the Cabrillo NM rocky intertidal monitoring program
2. Determine status and trends of intertidal resources
3. Document changes in biodiversity of intertidal resources

4. Evaluate influences (drivers/stressors) of intertidal habitat
5. Determine the effects of the San Diego Bay waters on marine water around Point Loma
6. Inventory intertidal habitats on the San Diego Bay side of Point Loma
7. Inventory subtidal habitats

1.11.1.2 March 2003 Workshop Results

The March 2003 workshop built upon the results of the January 2000 workshop and included additional background information on the Point Loma ecosystem that had been developed by park and network staff. The workshop was held with the following objectives in mind:

1. To review a proposed ecosystem conceptual model in light of the list of natural resources of concern
2. To review the criteria proposed for ranking the candidate vital signs
3. To prioritize the candidate vital signs using an interactive database approach

The conceptual models presented included all of the natural resources identified in the first workshop as well as the addition of resources, processes, or structures that were thought to be critically important by park and network staff in the evaluation and selection of vital signs for monitoring. Participants were asked to review the models, identify which, if any, factors were missing and to clarify pathways of interaction within the models that would be critical to understand in any monitoring program.

The primary ecosystem resources, processes, or structures that were considered of vital significance to the Point Loma ecosystem include:

- Air chemistry
- Climate/weather
- Succession (Vegetation Dynamics)
- Biomagnification/bioaccumulation
- Nutrient dynamics
- Habitat fragmentation
- Disturbance events
- Sound
- Light pollution
- Autecology of selected species (Marine and Terrestrial)
- Biotic interactions of selected species and communities (Marine and Terrestrial)
- Hillslope features and processes (Topography & Surficial Geomorphology)
- Soil quality
- Fluvial features and processes
- Coastal features and processes
- Water quality (Marine and Freshwater)

A process to systematically prioritize candidate vital signs based on a modification of the Analytical Hierarchy Process (Schmoldt & Peterson, 2000). Details of this process can be found in Appendix VI. Specific attributes of each of the above elements were identified as candidate vital signs and presented to the participants in a spreadsheet format for their review and evaluation.

Many questions were raised about the ecological context of the candidate vital signs. Participants felt the ranking criteria qualifying statements were too subjective, and indicated that without more information on the context of the candidate vital signs there was a high probability that significant variation in response and interpretation would confound the prioritization process. These issues were of sufficient significance that the group did not complete the prioritization exercise. Instead, recommendations to provide more context to the candidate vital signs were made. These recommendations were used to restructure the database ranking process that was later presented as a web based exercise for both Cabrillo NM and Santa Monica Mountains NRA. This process is described in section 3.3 below.

As part of the conceptual model review, the group provided input on further refining and defining of the significant resources, processes, and structure of the Point Loma ecosystem, and recommended that to improve the model it was necessary to:

1. Define the spatial limits of the model more precisely
2. Include geomorphology, i.e., topography and hydrology
3. Account for the differences in east-facing versus west-facing sides of the park
4. Expand anthropogenic impacts to include park buildings, facilities, and facilities management activities, and resource management
5. Expand the marine aspects of model providing much greater detail than as presented

A complete report on the outcome of the workshop is presented in Appendix VI.

1.11.1.3 Monitoring Questions

Twenty-seven monitoring questions for Cabrillo NM were derived from the workshops and conceptual model development (Table 1.9). From these questions were derived the list of final candidate vital signs that were presented in the web based prioritization exercise.

1.11.2 Channel Islands National Park

Early in the 1990s, two monitoring planning sessions were held at Channel Islands National Park. These sessions included park staff, outside scientists, and managers of agencies and organizations directly involved with resource management issues within the park. In September of 1999, after acquisition of land on Santa Cruz Island, a workshop was held to identify natural and cultural resource management needs specific to Santa Cruz. Channel Islands National Park first received funding in 1992 to begin vital signs monitoring. As a prototype long-term monitoring park, Channel Islands National Park developed a process for identifying vital signs of ecosystem integrity and proposed a step-wise planning process that emphasized the importance of preparing a conceptual model of park ecosystems before determining the actual vital signs to be monitored.

Monitoring planners at Channel Islands National Park developed a step-down diagram (Figures 1.11, 1.12, & 1.13) to illustrate a tactical plan for development of their monitoring program (Davis, 1983). Projects identified in the plan were then prioritized by the park staff and funded in priority order. The criteria used for this priority setting exercise included the ecological significance, socio-political, and legal status of the taxa proposed for monitoring.

The goals of the Channel Islands National Park Long-term Monitoring program are to:

- Determine present and future health of ecosystems,
- Establish empirical limits of variation in resources,
- Diagnose abnormal conditions in order to identify causal factors in time to develop effective mitigation, and
- Identify potential agents of change.

Table 1.9 Monitoring Questions developed for Cabrillo National Monument.

Park	Source	Monitoring Questions
Cabrillo National Monument	Conceptual Model	1. What affect is the absence of fire having on vegetation community structure in CABR?
		2. What are the status and trends in marine water quality surrounding Point Loma and CABR, and what is the status of 303d listed water bodies along Point Loma?
		3. Are anthropogenic generated contaminates present in the marine waters around CABR in sufficient concentrations to impact intertidal biota and designated use of these waters?
		4. What is the effect of resource management, research, monitoring, and visitor use on the marine intertidal resources of CABR and Point Loma?
		5. What is the incidence of occurrence and minimum temperature level and duration for frost events affecting network parks?
	Workshops	6. What are the status and trends in distribution and abundance of rare or endangered plants within CABR, the PLER, and other associated open space on Point Loma?
		7. What sensitive or rare species of terrestrial arthropods exist within CABR, the PLER, and other associated open space on Point Loma?
		8. What problematic or disturbance dependent invasive terrestrial arthropods are present within CABR, the PLER, and other associated open space on Point Loma and what is their distribution and abundance?
		9. What are the long-term trends in bird populations and diversity using regular counts of roost sites within CABR, the PLER, and other associated open space on Point Loma?
		10. What are the population trends of resident and migrant breeding birds using point counts collected annually during breeding surveys within CABR, the PLER, and other associated open space on Point Loma?
		11. What are the status and trends in raptor species populations within CABR, the PLER, and other associated open space on Point Loma?
		12. What are the status and trends in shore bird populations within CABR, the PLER, and other associated open space on Point Loma?
		13. What are the status and trends in species diversity of terrestrial arthropods within CABR, the PLER, and other associated open space on Point Loma?
		14. What potential habitats exist for the establishment of rare and endangered plant populations within CABR, the PLER, and other associated open space on Point Loma and how is this habitat changing?
		15. What is the status of the endangered brown pelican and other sensitive species including cormorants and herons within CABR, the PLER, and other associated open space on Point Loma?
		16. What non-native invasive plants occur on newly disturbed sites within CABR, the PLER, and other associated open space on Point Loma and are the dynamics of these invasions changing native plant and animal community structure on Point Loma?
		17. Are ongoing restoration efforts to eliminate exotic species within CABR, the PLER, and other associated open space on Point Loma successful?
		18. What is the effect of sediment enrichment in intertidal communities of Point Loma?
		19. What is the effect of sediment enrichment on marine water quality (turbidity) at Point Loma, and is there an associated effect on nektonic and planktonic species?
		20. What are the effects of substrate instability on benthic intertidal plant and animal communities of Point Loma?
		21. Is the rate of erosion of the Cabrillo formation stable, increasing or decreasing within CABR, the PLER, and other associated open space on Point Loma?
		22. What are the status and trends in the population of diving birds frequenting the waters around Point Loma?
		23. What are the effects of consumptive harvest of offshore marine resources on the intertidal community of CABR, the PLER and Point Loma (in general)?
		24. What are the status and trends in meso-carnivore populations within CABR, the PLER, and other associated open space on Point Loma?
		25. Are population characteristics of reptiles and amphibians increasing or decreasing? What is the range of reptile and amphibian species diversity and is this range increasing or decreasing?
		26. What are the status and trends in small mammal populations (of specific interest are rabbits and squirrels) along a north to south gradient within CABR, the PLER, and other associated open space on Point Loma?
		27. What are the status and trends in the marine intertidal vegetation community?

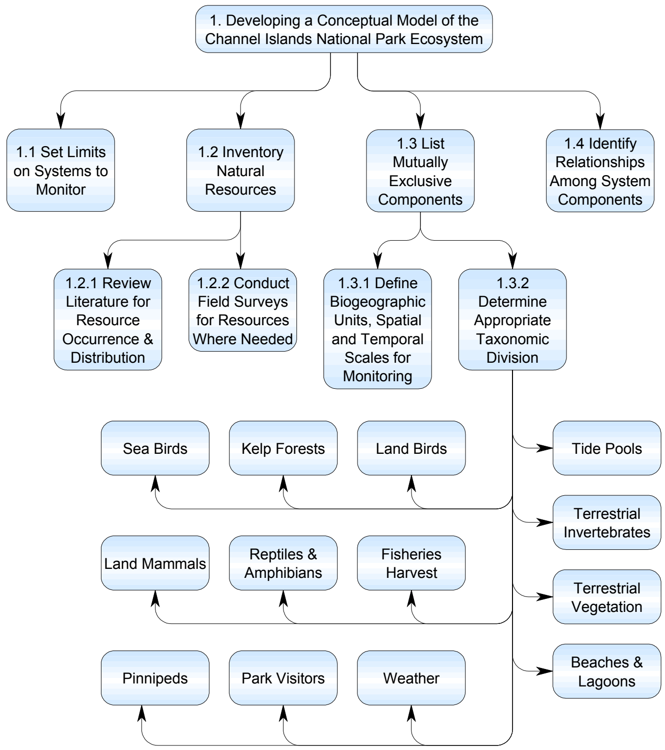

Figure 1.10 Develop a Conceptual Model. Step 1, of the Channel Islands Step-down Planning Process.

Design of a long-term monitoring program began with a conceptual model of the ecosystem. This model consisted of an exhaustive list of mutually exclusive system components and a description of their relationships. From these components, such as birds, vascular plants, and water, representative elements (e.g., species and watersheds) were selected and investigated for feasibility of monitoring based on levels of variation and ease and effectiveness of measurement. Not all parts of the ecosystem could be monitored, but the list of components for consideration included all biotic and abiotic resources and the processes by which they interact.

A population dynamics monitoring approach was selected for the Channel Islands model because it best met the management requirements: of accurately reflecting ecosystem conditions, providing ready interpretation, providing projections of future conditions, utilizing readily available sampling techniques, and providing information applicable to management at the species or population level. This approach is generally different from an approach stressing ecological effects on resources or attributes related to major drivers and stressors in the ecosystem. Population dynamics of selected species offer relatively unambiguous insights into ecosystem structure and function. Organisms integrate the effects of a vast array of ecological factors, including predation, competition, and environmental conditions that are expressed as changes in readily measured population parameters such as abundance, distribution, growth, and mortality.

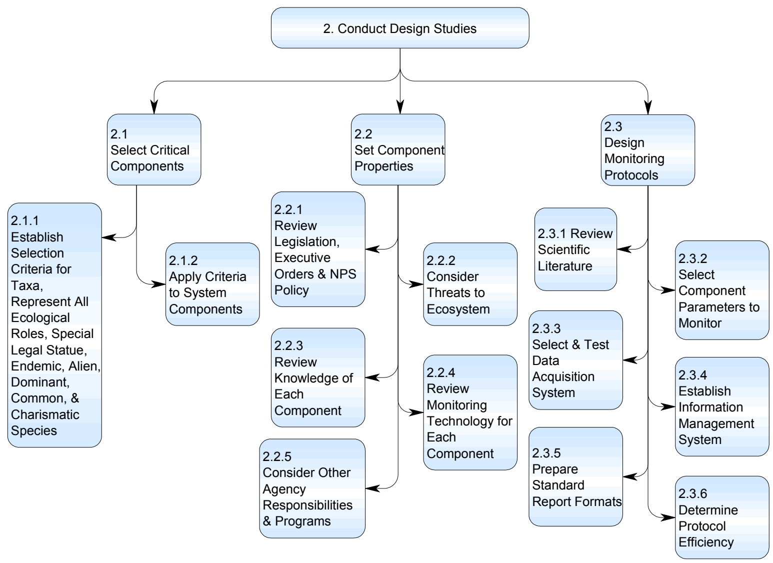

Figure 1.11 Conduct Design Studies. Step 2, of the Channel Islands Step-down Planning Process.

Division of Channel Island's ecosystems along taxonomic lines led to the identification of 13 system components that could be monitored at the population level (bottom half of Figure 1.10). A Delphi decision making approach was implemented in which experts for each taxon were asked to design monitoring protocols. Each design study had the same five objectives: 1) base monitoring on historical approaches and data whenever possible; 2) select or develop sampling techniques that are robust to observer variability; 3) utilize standard analytical techniques; 4) design reporting formats to archive and clearly communicate immediate findings; and 5) evaluate the utility of the protocol by field testing the sampling, analytical, and reporting systems for at least one year. Twelve detailed monitoring protocol handbooks were subsequently published.

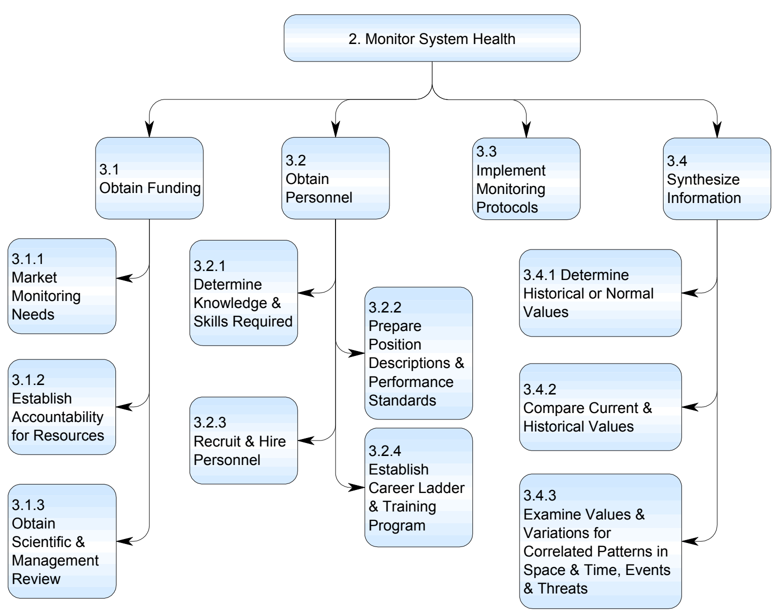

Figure 1.12 Monitor System Health. Step 3, of the Channel Islands Step-down Planning Process.

The selected taxa had to be representative of the entire ecosystem to be monitored. Seven criteria were applied to existing species lists to select taxa for monitoring design studies. Existing species lists of two groups, terrestrial invertebrates and the amphibians and reptiles, were inadequate for application of selection criteria. Thus additional field surveys or inventories were required before the selection criteria could be applied. The first criterion was that the final lists include a broad array of ecological roles and examples of many different trophic levels and life forms. Examples of this ecological and trophic diversity include primary producers to top carnivores, sessile invertebrates to wide ranging pinnipeds and sea birds. Special consideration was given to species that characterized entire communities or were exceptionally common, such as giant kelp and purple sea urchins (*Strongylocentrotus purpuratus*). Organisms with special legal status, such as State or Federally listed endangered species and marine mammals, were also included. Park endemics and aliens, and those species legally harvested from the park were also selected. Finally, if all other criteria were equal, charismatic or "heroic" species were selected because they had already garnered public support and understanding.

1.11.3 Santa Monica Mountains NRA

Between 1995 and the present, over 15 mini-workshops or monitoring workgroups were held to plan inventory and monitoring activities within Santa Monica Mountains National Recreation Area. Noteworthy among these were two international workshops featuring invited participants from South Africa and Chile. The international workshops were co-sponsored by the University of California Los Angeles, and focused on managing conservation lands and parklands in Mediterranean-type ecosystems. Resource managers at Santa Monica Mountains began to conceptualize and incorporate long term monitoring into park resource management plans as early as 1994, and many of these workshops and working groups preceded the formal inauguration of the service-wide I&M program. Specific resource management goals articulated in these plans include:

1. Obtaining resource knowledge and understanding
2. Implementing conservation and restoration actions
3. Determining status and trends of ecosystem health
4. Establishing empirically normal ranges of variation of ecosystem resources and processes
5. Providing early diagnosis of abnormal conditions that require intervention
6. Identifying potential agents of abnormal change to guide research and prescribe treatments.

In December 2002, a two-day conceptual modeling and vital signs development workshop was held for the Santa Monica Mountains National Recreation Area. Some 60 participants from academia, state and federal resource management agencies, and private industry spent two days discussing the proposed conceptual model and suggesting candidate vital signs (Appendix VII). Three breakout sessions (Vegetation, Terrestrial Fauna, and Rocks, Water, & Mud) provided significant comments on the conceptual model. The vegetation and terrestrial faunal workgroups proposed development of eight ecosystems sub-models to capture significant aspects of the functioning of the Mediterranean-type ecosystem of southern California. These eight sub-models were:

1. Geology/Soils/Vegetation
2. Climate/Cryptobiotic Crusts/Vegetation
3. Fire/Exotics/Vegetation
4. Fauna/Vegetation
5. Terrestrial Vertebrates (from a vegetation perspective)
6. Bats
7. Birds
8. Wildlife

Specifics of some of these models are presented in chapter 2 of this report and entirely in Appendices VIII & X

The Rocks, Water & Mud discussion group had difficulty working with the idea of a conceptual model. Geology and Climate were the only natural drivers considered by this group. There was some concern that monitoring background processes would prove of little value as the most important changes were caused by anthropogenic activities which are not natural drivers or stressors. Acute impacts from human activity were considered unpredictable and, therefore, difficult to monitor except as isolated post-impact events. A three-layer approach was suggested for conceptualizing the ecosystem, a natural system layer, a human system layer, and a disturbance layer. Drainage basins or watersheds were identified as the fundamental unit of concern from a geomorphological perspective and it was recommended that a primary consideration should be given to a complete characterization of these features. The group attempted to develop component elements for the three layers of ecosystem function but was unable to suggest unique disturbance factors that were independent of the natural and human systems layers. See Appendix VII for a discussion of the results of this workshop and specifically the recommendations of the rocks, water, and mud discussion group.

1.11.3.1 Monitoring Questions

Thirty-two monitoring questions specific to Santa Monica Mountains National Recreation Area (Table 1.10) drove the identification of candidate vital signs were suggested by workshop participants, the conceptual model and, from indicators of ecosystem health proposed for the nation by the H. John Heinz III Center for Science, Economics and the Environment (Anonymous, 2002).

In addition to the monitoring questions specific to either Cabrillo NM or Santa Monica Mountains NRA, eleven monitoring questions of general application across the breadth of the Mediterranean Coast Network were identified through workshop discussion, development of the conceptual model, reviewing the State of the Nations Ecosystems (The Heinz Center, 2002), and guidance received from the NPS Water Resources Division (see Table 1.11)

Table 1.10 Monitoring questions for Santa Monica Mountains NRA.

	Source	Monitoring Questions
Santa Monica Mountains NRA	Conceptual Model	1. What is the status of stream flow in historically ephemeral streams?
		2. What are the status and trends in the distribution of vegetation habitat types?
		3. What is the present fire return interval and is it changing?
		4. What are the status and trends in the ratio of exotics to native species in riparian communities?
	Heinz Center, 2002	5. How is the ratio of grasslands and scrublands changing over time?
		6. What is the number and pattern of zero-flow days in streams?
	SAMO Workshop	7. What is the trend in stream water chemistry (contaminates)?
		8. What are the status and trends in riparian community dynamics?
		9. What are the status and trends in Lichen population and community dynamics?
		10. What are the trends in visitor use statistics and how is visitor use impacting trails in SAMO?
		11. What are the status and trends in pollinator population and community dynamics?
		12. What are the status and trends in population and community structure in focal, at-risk, and functional species of importance in SAMO?
		13. What are the status and trends in the distribution and abundance of cryptobiotic crusts?
		14. What are the status and trends in post-fire plant community recovery?
		15. How are scenic landscapes changing over time?
		16. What are the status and trends in plant community structure and cover?
		17. What are the status and trends in rare species population and community dynamics?
		18. What are the status and trends in the ratio of non-native grasses to native forbs?
		19. What is the abundance and distribution of vertebrates and crayfish in SAMO streams?
		20. How is habitat structure changing?
		21. How is spatial/temporal variation in stream flow changing?
		22. What are the status and trends in exotic plants species population dynamics?
		23. What effect are extreme storm events having on hillslope and coastal erosion, and is this process changing the structure of coastal lagoons?
		24. What are the status and trends in basic climatic parameters?
		25. What is the change in land cover over time in SAMO?
		26. How has habitat fragmentation changed over time?
		27. How are size, timing, and distribution of fires changing over time in SAMO?
		28. What are the status and trends in populations of aquatic invertebrates in mountain streams?
		29. What is stream condition based on stream morphology?
		30. How are roads influencing the frequency and severity of debris flows and how is stream condition affected by debris flows?
		31. How is spatial/temporal variation in hillslope flow changing?
		32. How is habitat connectivity changing?

Table 1.11 Monitoring questions of general application across the Mediterranean Coast Network.

	Source	Monitoring Questions
Mediterranean Coast Network	Conceptual Model	1. What are the status and trends in the rate of soil erosion within MEDN parks?
		2. What are the status and trends in the frequency and intensity of present-day flood/erosion cycles within MEDN parks?
		3. What are the status and trends in the length of summer drought in the MEDN parks?
		4. What are the effects of landscape fragmentation and loss of connectivity on large or meso-carnivores?
		5. What are the effects of landscape fragmentation and loss of connectivity on amphibians and reptiles?
		6. What are the status and trends in bat species diversity, and distribution and abundance?
	Heinz Center, 2002	7. Is the level of nitrates stored in ground water changing?
		8. What are the trends in invasive bird population dynamics?
		9. Is the depth to shallow ground water changing over time?
	NPS – Water Resources Division	10. What are the status and trends in Water Quality of park streams, ponds, seeps, springs, & lagoons?
	SAMO Workshop	11. What are the status and trends in Ambient Air Quality?

2 Conceptual Ecological Models

Vital signs ('physical, chemical, and biological elements and processes of … ecosystems that … represent the overall health or condition of … resources") must be related to a "well-understood and generally accepted conceptual model of the system to which (they are) applied" (National Research Council, 2000; Jackson *et al.*, 2000; Cairns *et al.*, 1993). "A conceptual model is a visual or narrative summary that describes the important components of the ecosystem and the interactions among them. Development of a conceptual model helps in understanding how the diverse components of a monitoring program interact, and promotes integration and communication among scientists and managers from different disciplines."[12] The process of institutionalizing long-term monitoring of selected ecosystems components or processes considered to gauge ecosystem stressor intensity, structural integrity, or resource condition is only as good as the conceptualization of the system to be monitored and the understanding of the functional role of each resource element or process in the system (King, 1993). Preparing a conceptual model requires some definition of the spatial scale of the ecosystem to be modeled, a perception of the temporal extent of influence of the signficant elements of the system, and a feeling for the hierarchial nature of the components or proceses being modeled. If successful in coming to grips with these issues then a conceptual model can accurately reflect the relationships among ecosystems attributes, elements or processes of importance instead of being just a description of "that ecological stuff out there, over there" (King, 1993 paraphrased).

2.1 Southern California Mediterranean-type Ecosystem Conceptual Model

The Mediterranean-type ecosystem of southern California has been identified as one of the world's "hot spots" for biodiversity. It is an area of relatively small size with tremendous biological richness. Natural disturbance regimes in southern California include summer drought, tectonic instability, flood and erosion cycles, and fire. By synthesizing information obtained from published literature, workshop discussion groups, park resource managers, and academic subject matter experts a general model of ecosystem functional relationships based upon identifying ecosystem drivers, stressors, and ecological effects of the drivers and stressors was developed for Santa Monica Mountains National Recreation Area, Cabrillo National Monument, and to a lesser extent Channel Islands National Park. The results of this effort are presented in Table 2.1.

Table 2.1 attempts to capture all major influences (drivers and stressors) and the potential effects of those influences on natural elements of the Southern California Mediterranean-type ecosystem. Graphic models produced from the information in table 2.1 focus on the Santa Monica Mountains and were used as a surrogate model for Cabrillo National Monument specifically in relation to general vegetation community structure and function. The Channel Islands monitoring program has been functioning for a decade or more, and no new vital signs or ecosystems attributes are expected to be added to their program. Therefore, the Channel Islands were not included in the development of detailed graphic models. With a little modification and some imagination the Santa Monica Mountains model can be considered to be representative of the Channel Islands ecosystem as well.

Ecosystem drivers are forces either intrinsic or extrinsic to an ecosystem than have large scale influences on the processes or components of an ecosystem. These can include, but are not limited to, land-use changes, consumptive extraction of resources, climate, fire, earthquake etc.[13] Five primary drivers for Mediterranean Coast Network park ecosystems were identified, and in turn subdivided into specific elements that were considered to be significant aspects of the drivers that notably contribute to ecosystem function and structural integrity. Ecosystem stressors as identified in this process were considered to be significant activities, actions, events, or processes that can alter the self-organizational properties or integrity of ecosystems. Ecological effects were those processes or components of the ecosystem that were most responsive to the effect of the stressors and would point towards specific

[12] http://www.nature.nps.gov/im/monitor/index.htm#Conmodel
[13] http://www.evergladesplan.org/pm/recover/recover_map.cfm

attributes of the ecosystems that could be quantified and monitored over time. Other components of park ecosystems that do not necessarily follow a driver stressor relationship were included when developing the graphic models and in developing monitoring questions and identifying attributes of ecosystem health. These included specific resources such as focal species or other biotic groups or species that are of significance within park ecosystems, and ecosystem structure such as geomorphology, vegetative dynamics, nutrient processes, and water quality (both marine and freshwater). These additional aspects of ecosystem organization were introduced to facilitate the construction of a relational database for prioritizing candidate vital signs for developing the monitoring program.

Table 2.1 Summary of ecosystem drivers, stressors, and ecological effects aggregated within structural or functional elements of Mediterranean-type ecosystems as proposed for the National Park Service units of the Mediterranean Coast Network (Cabrillo National Monument, Santa Monica Mountains National Recreation Area, & Channel Islands National Park.)

Ecosystem Drivers	Ecosystem Stressors (Agents of Change)	Ecological Effects (Response, Things Affected)
Parent Materials (Geology)		
• Geology • Soils • Topography • Geological Change • Hydrology	♦ Erosion ♦ ♦ ♦ ♦	▪ Sediment & Nutrient Transport ▪ Toxic Materials Transport & Accumulation ▪ Water Budget ▪ Water Quality ▪ Mass Wasting ▪ Geologic Stability ▪ Altered Soils Structure
Climate (Weather)		
• Precipitation • El Niño • Climate (Temperature) Change • Fog • Ocean Currents	♦ Flood ♦ Drought ♦ Winds ♦ ♦ Erosion ♦ ♦	▪ Mass Wasting ▪ Altered Soils Structure ▪ Vegetation Habitat Type ▪ Exotic Propagule Transport ▪ Fire Susceptibility
Fire		
• Fire Return Interval • Fire Seasonality • Fire Intensity	♦ ♦ ♦ ♦ Starts ♦ ♦	▪ Community Structure ▪ Colonization & Dispersal of Exotics ▪ Native Community or Population Genetics ▪ Water Budget ▪ Water Quality ▪ Seed Bank Structure ▪ Vegetation Community Type
Anthropogenic Impacts		
• Land Use Conversion • Urbanization • Direct Human Contact	♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ & non-Horticultural Exotics ♦ ♦ ♦ ♦ ♦	▪ Native Community Structure ▪ Colonization & Dispersal of Exotics ▪ Native Community & Population Genetics ▪ Water Budget ▪ Toxic Materials Accumulation ▪ Habitat Structure & Composition ▪ Vegetation Habitat Type ▪ Migration & Dispersal ▪ Water Quality ▪ Air Quality ▪ Visibility ▪ Wildlife Reproductive Success

Ecosystem Drivers	Ecosystem Stressors (Agents of Change)	Ecological Effects (Response, Things Affected)
	♦ Grazing by Introduced Species ♦ ♦ Aircraft ♦ ♦ ♦	▪ Species Loss ▪ Disease ▪ Wildlife Behavioral Changes ▪ Resource (Food) Availability ▪ Altered Hydrology
Biological Processes		
• Succession (Community Dynamics) • Evolution • Species Range Dynamics	♦ ♦ Invasion ♦ ♦ ♦ Extirpation ♦ Drift ♦ Disease ♦ Diversity ♦ Diversity ♦ Competition ♦ Predation ♦ ♦	▪ Habitat Type Conversion ▪ Genetic Change ▪ Community Structure ▪ Predator/Prey Dynamics ▪ Population Dynamics

*Beyond the range of normal variation.

2.2 Ecosystem Drivers & Stressors of the Mediterranean Coast Network

The dynamic interaction of ecosystem drivers and stressors creates an ecological regime of relations among ecosystem components that in stable regimes preserves the normal and desirable self-organizational capacity of the system. When extreme events or shifts in the state of a driver or stressor occur or when a new (anthropogenic) stressor is introduced to an ecosystem the dynamic interaction among ecosystem components and processes can be interrupted or altered in such a manner that a shift in the self-organizational regime can occur. This regime shift can destabilize an ecosystem increasing the variation in the normal or natural dynamic process of the system and may cause the system to cross a threshold in stability and move away from the accepted or normal self-organizational state or integrity desired by resource managers etc.

The following ecosystems drivers and associated stressors have been identified as significant and critical components or processes of the southern California Mediterranean-type ecosystem.

2.2.1 Geology (Parent Materials)

The Mediterranean Coast Network of National Parks lies wholly within the Southern California Mountains and Southern California Coastal Plain Major Land Resource Areas (MLRA) of the United States. Elevation of the Southern California Mountains MLRA ranges from 600 to 2,400 m. These strongly sloping to precipitous mountains have unstable slopes and sharp crests. Valleys are narrow, and many have streams actively eroding by bank cutting. Elevation of the Southern California Coastal Plain MLRA[14] ranges from sea level to 600 m. These gently to strongly sloping and dissected coastal plains are bordered by steep hills. Rock outcrops are common.

[14] http://www.essc.psu.edu/soil_info/soil_eco/

All of southern California is located in a highly active tectonic region where strong ground shaking can result from earthquakes on nearby or more distant faults. Potential seismic effects include ground ruptures along fault lines, vertical amplification of earthquake energy, and earthquake-induced soil liquefaction.

The Santa Monica Mountains are the southern-most mountain chain in the east-west trending or transverse ranges of southern California. The four northern-most islands of Channel Islands National Park are thought to be the western extension of this mountain range. Numerous faults, folds, down warps, and a complex geologic structure characterize this area. The western end of the mountains is igneous in origin shifting to a largely sedimentary base in the east. Due to a combination of steep unstable slopes and poorly cemented sedimentary bedrock, the Santa Monica Mountains are prone to landslides. The 1994 magnitude 6.7 Northridge earthquake which was centered 18 km below ground and ≈ 40 km east of the geographic center of the Santa Monica Mountains triggered more than 1,400 individual landslides within the mountains. The shrink-swell behavior and erodibility of soils is an important concern throughout the Santa Monica Mountains. Soil erosion typically results from concentrated runoff on unprotected slopes or along unlined streambeds. Debris flows occur with some regularity where sufficient sediment mixes with water flow to form a thick slurry of water, soil, and rock. The mountains are a complex assemblage of marine and non-marine deposition. The topographical relief is a result of differential erosion and plate tectonics.[15]

The Channel Islands include examples of some of the most extensive marine terraces in the world and contain many sea caves, rugged shorelines, sandy beaches, mountain peaks, and valleys. Eolian landforms with active dunes are also present in the islands. Santa Barbara Island was formed by underwater volcanic activity and emerges from the ocean as a giant twin-peaked mesa with steep cliffs. Santa Barbara Island also features considerable diversity in habitats, with steep cliffs, narrow rocky beaches, canyons, and badlands areas.

Cabrillo National Monument lies within the coastal plain region of San Diego County which is underlain by a "layer cake" sequence of marine and non-marine sedimentary rock. Over geologic time periods the relationship of land and sea has fluctuated drastically. Faulting related to the local La Naçion and Rose Canyon fault zones has broken up this "layer cake" sedimentary sequence into a number of distinct fault blocks in the southwestern part of the county. Significant exposures of late Cretaceous-aged marine sedimentary rocks occur in the sea cliffs along the west side of the Point Loma Peninsula.[16]

Various geological factors can directly affect the distribution and abundance of vegetation types within the Mediterranean-type ecosystem of Southern California. Soil volume, depth to bedrock, bedrock fracturing, slope, aspect, soil structure, and erodability are just a few of the geologic or parent materials features that can determine vegetation community structure. These features when interacting with climate (rain fall), ground water, and water storage capacity are significant determinates of plant community establishment and maintenance. Mixed chaparral vegetation is most common on north-facing slopes with shallow soils. Chamise chaparral dominates on south-facing slopes with rocky soils. Establishment of both of these communities is dependent upon regular annual rainfall in excess of 350 mm. Coastal sage scrub vegetation dominates in similar areas with less than 350 mm of rain fall each year. Native bunchgrass is generally found on nutrient poor clay soils. Valley oak savannas and live oak woodlands occur where the soil is deeply weathered and able to hold significant amounts of moisture. Wetlands and riparian communities are found in areas with deeply fractured bedrock or poorly consolidated sediments that are permanently saturated or allow ground water flow at shallow depths (Figure 2.1).

2.2.2 Climate

Summers are dry in the Southern California Coastal Plain MLRA; average annual precipitation ranges from 25 to 62 centimeters. Average annual temperature ranges from 16º to 18º C, the average freeze-

[15] Santa Monica Mountains General Management Plan, In Press.
[16] http://www.sdnhm.org/research/paleontology/sdgeol.html

free period ranges from 365 days along the coast, decreasing to 250 days in the hills.[17] The Mediterranean climate regime, typical of the Mediterranean Coast Network, consists of hot, droughty summers and winter rain. In summer, the high-pressure belts of the subtropics drift northwards in the Northern Hemisphere (May to August), and southwards in the Southern Hemisphere (November to February), coincident with substantially higher temperatures and little rainfall. During the winter, these high-pressure belts drift back towards the equator, and the weather becomes dominated by rain-bearing low-pressure depressions.

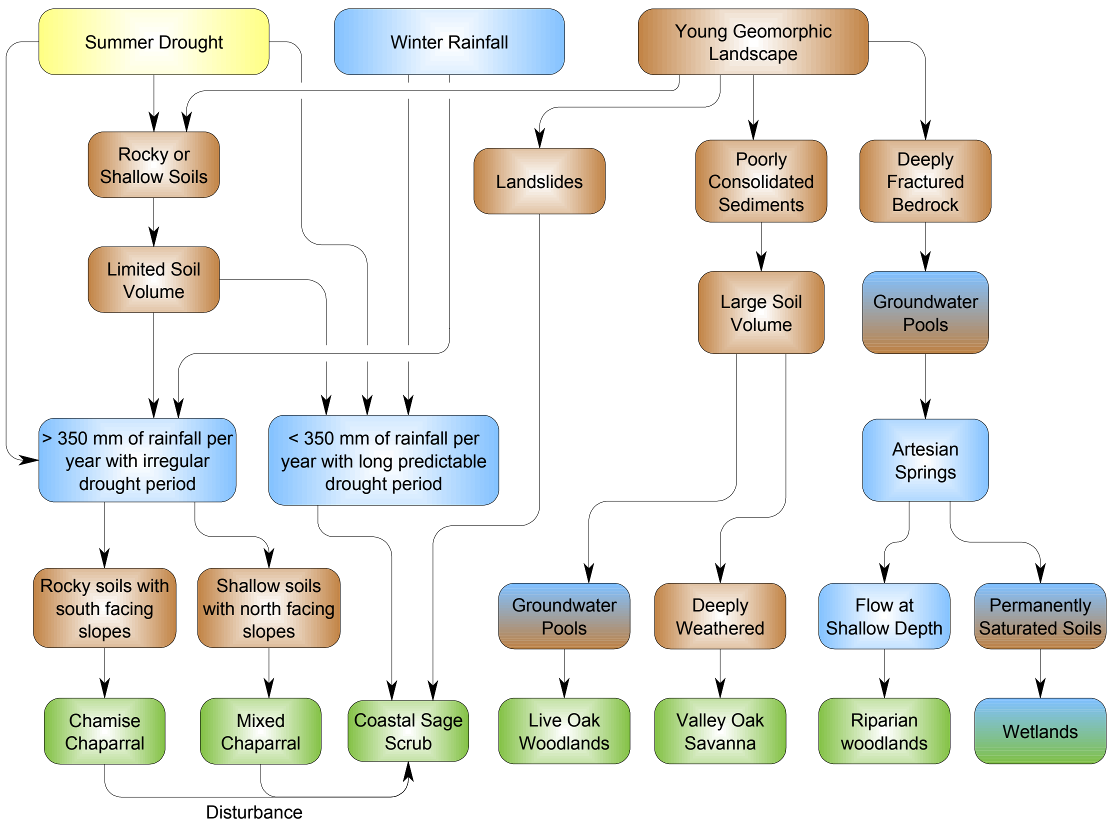

Figure 2.1 Vegetation community model presenting the dynamic influences of rainfall, soil moisture, and geomorphology on the establishment and maintenance of vegetation communities within the Mediterranean-type ecosystem of the Santa Monica Mountains.

One of the most significant factors to affect climate in the Mediterranean Coast Network is El Niño, a climatic anomaly resulting from the occasional development of warm surface waters in the Pacific Ocean along the coast of equatorial South America. The formation of El Niño is linked with the cycling of a Pacific Ocean circulation pattern known as the El Niño Southern Oscillation or ENSO. In a normal year, low atmospheric pressure develops over northern Australia and Indonesia, with high pressure over the Pacific. Consequently, winds over the Pacific move from east to west. The easterly flow of the trade winds carries warm surface waters westward bringing rainstorms to Indonesia and northern Australia. Along the coast of Peru and Ecuador, cold deep water wells up to the surface to replace the warm water that is pulled to the west.

[17] http://www.essc.psu.edu/soil_info/soil_eco/

In an El Niño year, low pressure over northern Australia is replaced by high pressure, while air pressure falls over large areas of the central Pacific and along the coast of South America. This change in pressure pattern causes the normal easterly winds to be reduced and sometimes reversed, allowing warm equatorial water to flow or “slop” back eastward across the Pacific accumulating along the coastlines of Peru and Ecuador. Warm moist air on the eastern side of the Pacific may lead to drastically increased rates of rainfall and flooding. El Niño has the capacity to influence atmospheric wind patterns worldwide. Possible impacts include shifting of the jet stream, storm tracks and monsoons, producing unseasonable weather over many regions of the globe. Because El Niño may influence the mid-latitude Northern Hemisphere jet stream, the weather in Europe and North America can be influenced as well. El Niño effects in the Mediterranean Coast Network include wetter than normal winters with the possibility of significant flooding and localized warming of marine surface waters resulting in northward migration of subtropical species and the temporary loss of temperate marine algae (kelp) beds.

2.2.3 Fire

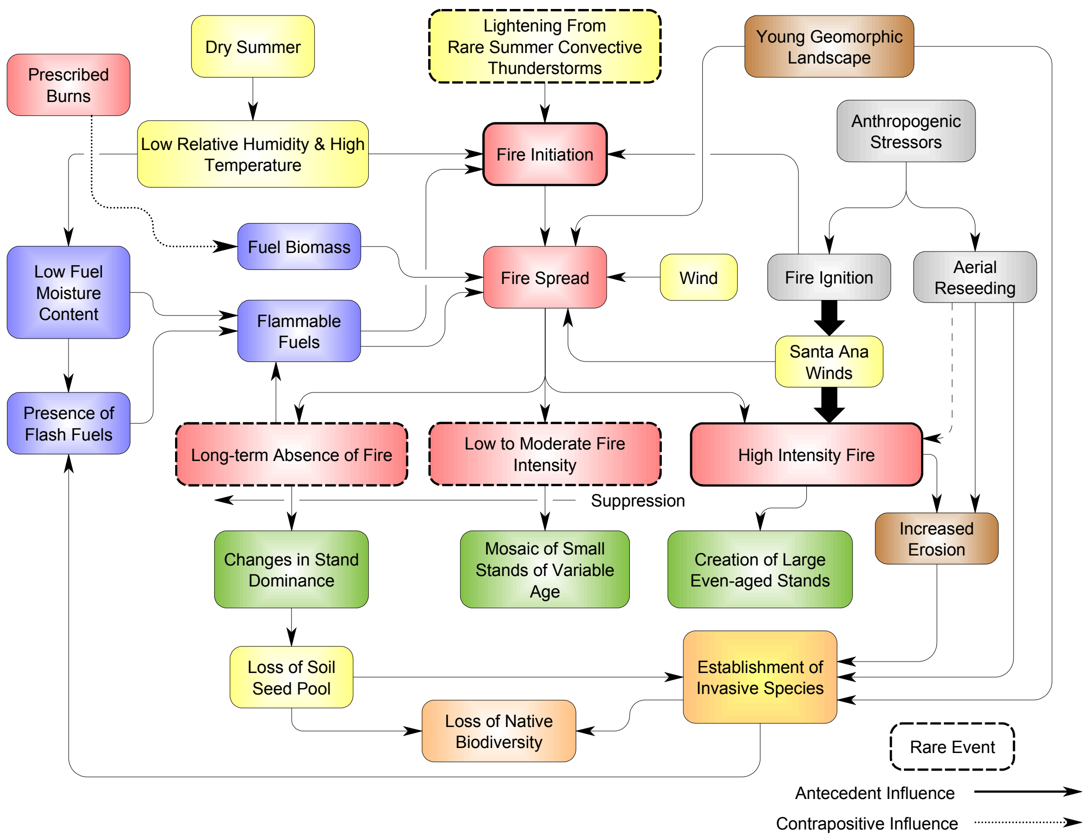

Figure 2.2 Role of fire in the Santa Monica Mountains and by extension the Mediterranean-type climate of Southern and Baja California.

Fire is a fundamental natural process contributing to ecosystem function, structure, and integrity in California chaparral (Figure 2.2 & Rundel 1998a). Lightening caused fires are rare in coastal or low elevation Mediterranean climate areas of California (Keeley, 1982 & 2002). It is during the months of extreme summer drought that chaparral vegetation is most susceptible to high intensity burning (Rundel, 1998a). Mediterranean-climate shrubs have been classified by their mode of post-fire regeneration as obligate seeders, facultative seeders, or obligate resprouters. There are two general modes of seedling recruitment: (1) disturbance-dependent species that restrict recruitment to post-fire conditions (gap species), and (2) disturbance-free species that recruit successfully only in the long-term absence of fire (gap-avoiding species). Disturbance-dependent species establish seedlings in the first year after fire. These species produce dense cohorts of even-aged shrubs that thin dramatically with time after a fire, and produce fruits that are not animal dispersed and seeds that may lie dormant for years. Being dormant, these seeds disperse more in time than in space. Seedlings arise from a long-lived permanent seed bank, and germination is cued either by intense heat or by chemical stimulus from smoke or charred wood (Keeley, 1998).

In chaparral, some species seldom establish seedlings after a fire, resprouting vigorously from lignotubers, and in respect to fire are termed obligate-resprouters. Seedling recruitment in these species occurs in older, more mesic stands and dense cohorts of seedlings are rare. Successful recruitment is generally restricted to beneath the shrub canopy and is absent from gaps. Mature shrubs produce fruit that are widely dispersed by animals. Soil seed banks are transitory because seeds are short lived and germinate easily with adequate moisture (Keeley, 1998).

Disturbance-dependent recruitment derives from readily available resources in post-fire environments, and natural selection has strongly selected for delaying germination to post-fire conditions. Summer drought in these hot, high light environments has imposed strong selection for physiological tolerance to water stress. Post fire recruitment has selected for rapid growth and against adventitious buds and lignotubers, leading to the obligate seeding mode. Obligate-seeding, with increased frequency of sexual reproduction, may have allowed for a greater physiological and anatomical fine tuning of adaptation to drought. With enhanced tolerance to drought there is less selective value in resprouting. Safe sites for recruitment are rare in time but when they occur they are spatially extensive. A high premium is placed on maintenance of deep seed dormancy and fire cued germination. Disturbance-free recruitment restricts seedling establishment to cooler, low light, moist conditions under the shrub canopy. These species are highly susceptible to drought induced embolism in xylem tissues and thus avoid summer drought by maintaining year round access to water with deep massive root systems. While this is good for adults it makes recruitment of seedlings in drought-prone environments a precarious and risk prone process (Keeley, 1998).

Changes in natural fire pattern from reduced fire return interval, increased fire intensity, or the introduction of fire into generally fire-free seasons can significantly impact vegetation community dynamics. A reduced fire return interval can eliminate disturbance dependent species by the repeated destruction of potential parent stock before they mature sufficiently to produce seed. Without seed production the normally large seed bank for these species is not replenished and these species disappear from the landscape. In areas where active suppression has resulted in the accumulation of fire-prone litter, fire intensity can be increased to the point that soil sterilization during a fire can occur to depths of up to 20 cm, severely impacting the seed bank of obligate reseeders and below ground lignotubers of obligate resprouters thus decreasing the potential for post-fire germination (Christensen, 1994). In southern California fire is most common in the fall when dry northeasterly winds known as Santa Anas exacerbate summer drought conditions and render the landscape extremely vulnerable to fire. Additionally, fire containment can be complicated by these frequent high winds. Fire outside of this time when soil moisture is high can result in the loss of the heat insulation capabilities of the soil to the in-ground seed bank of reseeders and below ground lignotubers of resprouters. When soil moisture is high, in the spring and winter months, deep heating of the surface soils can literally cook in-ground seeds and below ground plant structures eliminating the possibility for regeneration of the native plant community, which can result in habitat type-conversion from native perennials to alien annuals.

Fire can have a significant impact on the physical and chemical properties of surface soils. Except where soil heating is extreme, changes in the texture or mineralogy of surface soils are generally negligible. Weathering of exposed parent rock can result in chipping or splitting of exposed surfaces (Christensen, 1994). Loss of nutrients from ecosystems during fire results from: gasification and vaporization of compounds in the soil, convection of ash particles in fire-caused winds, leaching of ions out of the soil, and increased post-fire erosion. Nitrogen and sulfur rich organic compounds are readily oxidized and gasify during fire. Intense (high temperature) fires can also convert phosphates into gaseous phosphorus oxides. The impacts of fire on the physical and chemical characteristics of soils are magnified by steep terrain and infertile soils that characterize Mediterranean-type ecosystems (Christensen, 1994).

Fire can also impact the fundamental properties of animal communities such as species richness, composition, abundance, and energy flow. Soil and litter dwelling invertebrates can experience 50 to 90% mortality during fire. Fire induced mortality in reptiles is not well documented, and their susceptibility to fire may be ameliorated by their behavior and by the timing of a fire. Mammals are variably impacted by fire; some species are killed outright while others may be dispossessed. Those that survive do so by fleeing the fire front or taking refuge in underground shelters or nest sites. Post fire changes in animal communities vary by taxa. Mammals and reptiles show marked changes in species composition and abundance after a fire. Soil and litter dwelling invertebrates show significant reductions in number and diversity that may persist for several years. Richness and abundance of reptiles post-fire can increase dramatically because of changes in the mixture of cover and open areas for foraging and thermoregulation. While changes in bird populations are relatively short lived after a fire, mammals show the greatest short-term changes in response to fire. In the time immediately after a fire some small mammals can disappear entirely, others may only decrease, and others may show marked increases in numbers (Quinn, 1994).

2.2.4 Anthropogenic Influences

As with other Mediterranean climate regions, southern California is favorable to human habitation, agriculture, and recreational activities. Santa Monica Mountains National Recreation Area is located within metropolitan Los Angeles, a region of more than 16 million residents, and which is the second-largest metropolitan area in the United States. Likewise, Cabrillo National Monument is situated within the sixth-largest metropolitan area in the United States, and, although Channel Islands National Park has been buffered to a large extent by its inaccessibility and by its relatively stable historic land ownership patterns, proximity to the densely populated southern California mainland means that anthropogenic impacts and activities have had and continue to pose a significant threat to the island's ecosystems.

Anthropogenic stressors can be differentiated into chronic or acute and may cross the threshold from chronic to acute depending upon the scale of an event. Chronic stressors include habitat fragmentation, urbanization and land use conversion, establishment of invasive alien species, air pollution, and global climate change. Acute human caused stressors include water pollution, increased summer urban runoff, light pollution, overgrazing, and fire.

Anthropogenic impacts identified in the network conceptual ecosystem model can be grouped into three major categories: (1) impacts from current human land use; (2) impacts caused by growth and development (i.e. urbanization); and (3) impacts to natural areas caused by direct human contact with resources in the course of activities such as recreation, land management, consumptive use, and fire. Past land use practices are also a significant cause of environmental degradation at all three parks in the network. While these anthropogenic drivers are major ecosystem forces throughout the network, the extent to which these drivers and related stressors influence natural resources differs for each park.

2.2.4.1 Land Use

Human land use practices introduce a myriad of external pressures on natural systems. Stressors such as air and water pollution, night-lighting, alien species introductions, hydrologic changes, even localized climatic changes such as heat-island effects cause significant impact on natural systems and processes. Stressors may interact to produce complex ecological effects and behavioral modification in native wildlife. For example, landscaping of residential and commercial property has introduced hundreds of non-native plants that significantly affect the water budget for native communities by out-competing natives for available water. Conversely, domestic irrigation in the Santa Monica Mountains has resulted in increased surface water flow, transforming some ephemerally flowing streams to perennial flow and converting large areas of native woodlands or chaparral to riparian vegetation that while dominated by native species is not normal for the area.

Seeds from introduced alien plants are also transported throughout the mountains by these newly perennial streams. Pesticides and fertilizers used in domestic applications are also transported to undeveloped areas via increased surface water runoff. Fragmentation of habitat and reduction in habitat patch size and increased noise and night-time lighting can affect foraging and reproductive behavior of many species. In addition, highway construction can effectively create barriers to migration and also introduce a significant source of mortality to native wildlife.

When considering land use as a major driver for all three parks in the network, the types of land use and the resulting stressors can differ considerably among the parks. Cabrillo National Monument is isolated from other natural lands by the ocean and surrounding urban development. Thus, for Cabrillo, stressors related to urbanization are the most influential of this group. Land uses affecting the Santa Monica Mountains also include suburban, rural residential, and some agriculture. While Channel Islands National Park is buffered by the ocean from most localized land use impacts, regional impacts associated with urbanization such as air pollution and water pollution may still be critical stressors of natural resources within the park. Additionally, historic ranching, U.S. Coast Guard and U.S. Navy presence, hunting activities, and past ranching activities on the Channel Islands have introduced significant anthropogenic derived impacts to these otherwise isolated islands.

While land use impacts arising from human conversion of natural open space to developed lands is a significant stressor in southern California, impacts from human land use practices including impacts resulting from the dynamic expansion of developed lands, the intensification of existing land use patterns (density use changes), or conversion of rural development to urban development also introduce stress to remaining open space within the region. The major stressors arising from development are habitat loss and habitat fragmentation, both critical issues for the Santa Monica Mountains NRA. In the recreation area over 50% of the land is in private ownership and much of which is currently undeveloped (≈ 6000 parcels). Regional land values and local population growth ensure that development will continue within the park boundary. As habitat is converted to human uses, ecological effects may include reduced wildlife populations, increased wildlife/human interactions, and reduced biodiversity due to the loss of habitat specific species or species which require large amounts of habitat to persist. In addition, increased pressure on the remaining habitat will probably also occur, e.g., while major large-scale development encroaches on the outer boundary of the NRA, small-scale internal projects (e.g., small housing tracts, vineyard and orchard development, etc.) are subdividing and fragmenting the natural habitat throughout the mountains.

Aside from effects arising from the actual reduction in habitat area, ecological responses to habitat fragmentation may also include invasions of alien species (e.g. from residential landscaping or agricultural plantings), increases in populations of urban-associated species, loss of dispersal or migration opportunities, increased urban-wildland interface with concomitant edge effects (e.g., habitat degradation, changes in species composition, impacts from domestic animals, etc.), and increased wildlife/human interaction.

Cabrillo National Monument is, effectively, a protected island within an urban matrix, and is not subjected to continuing habitat loss and habitat fragmentation. Major anthropogenic drivers are related to continuing and persistent existing human activities such as recreation, military use, and surrounding urbanization. However, because of past growth and development, insularization is a potential stressor that may have ongoing ecological effects such as loss of bio- and genetic diversity. Similar ecological effects could be expected in the Santa Monica Mountains and surrounding natural areas as development surrounds and isolates remaining natural areas. While insularization is an important influence on the Channel Islands as well, it is a natural driver rather than anthropogenic stressor.

2.2.4.2 Direct Human Contact

Current land use and development are both largely external influences. The final group of anthropogenic stressors relate to human activities which directly affect park resources. These activities include parkland management practices as well as recreation, vehicle, and air traffic, commercial and sport fishing, wildland fire hazard fuel reduction, arson, accidental fire ignitions, and fire suppression activities.

At Cabrillo, intense pressure is placed on park resources by the huge volume of visitors (more than 1,000,000 annually in the past two decades) to such a relatively small park site. Nearby consumptive uses such as fishing and oil/gas extraction may indirectly affect park resources as well. For the Channel Islands, such consumptive uses are a significant direct stressor to the ecosystem. Visitation to the islands is relatively low, but may increase as mainland recreational opportunities are lost or overused. In the Santa Monica Mountains, proximity to the huge Los Angeles Metropolitan area and mild climate throughout the year means that there is a steady stream of visitors coming into the mountains for recreational and educational opportunities. Vehicle traffic, not only from park visitors, but from mountain residents, commuters from surrounding suburban areas, and summer beach-goers, are likely to have significant ecological effects as well.

Past land use practices have also had a major impact on network parks. This is particularly relevant in the Channel Islands where alien herbivores have grazed in large numbers and, in some cases, have only recently been removed. In southern California in general, "natural" areas have a long history of human use including Native American burning, agricultural grazing and cultivation. These uses have altered habitat structure, vegetation community structure and composition, and the distribution of alien species and will continue to cause ecological impacts in network parks.

2.2.5 Biological Processes

The sclerophyllous species that comprise the coastal southern California vegetation first appear in the fossil record in the middle and late Eocene as a component of the Madro-Tertiary Geoflora of western North America (Raven & Axelrod 1978). The current vegetation assemblage is dominated by shrublands whose physiognomy and composition is believed to result from a complex interaction of landscape diversity and climatic fluctuations, but which strongly reflects adaptation to the Mediterranean-type climate of moist winters and hot dry summers. These shrubland community types are held to be adapted to the periodic stand-replacing fires that are a significant characteristic of the environment and which act to perpetuate shrubland communities. However, only non-sprouting ("obligate seeding") species are truly fire-adapted in that seed germination requires stimulation by heat and chemicals released during fire and therefore, the persistence of these species in the community requires periodic fire events. Sprouting species on the other hand, employ a widely used regeneration strategy and are not adapted *per se* to fire. Although the persistence of non-sprouters is dependent on fire, the reason for their wide occurrence in South Coast chaparral is not immediately apparent. Davis *et al.* (1998) note that sprouters are advantaged in that they have two mechanisms of post fire recovery: previously acquired position (sprouting) and population expansion (seed germination). They reason that the persistence of non-sprouters is due to a genetic advantage resulting from production after each fire of an entirely new pool of genetically recombined individuals on which natural selection can operate. This would result in greater genetic diversity (i.e., greater speciation) and a quicker pace of evolution that has tracked the recent advent of a drier, fire prone climate in southern California.

Although fire is the most important natural disturbance in southern California coastal shrublands, vegetation dynamics are not determined simply by the occurrence of fire, but by a complex "fire regime" which includes fire frequency, length of the fire free interval, fire intensity and fire seasonality. All of these components are interrelated and interact with post-fire environmental and biotic factors to influence vegetation response. Water stress from summer drought and from radiative freezing in the winter is particularly important in determining post-fire seedling survivorship (Keeley 1998, Langan *et al.* 1997). Thus, variation in the fire regime and post-fire environmental conditions determines vegetation response and maintains biodiversity by variously favoring different species depending on their differing regeneration strategies and sensitivities.

Distribution of animal species generally follows vegetation community structure. Avian species are known to forage selectively within specific vegetation types. Reptiles require a mix of open space and vegetation cover. Herbivore distribution is often limited by their selectivity of forage. Fossorial herbivores require soils malleable enough to allow borrowing and proximity of appropriate forage. Various species of amphibians require significant amounts of water for life or to complete their life cycles. All of these factors are linked either directly to geologic conditions or linked indirectly through their choice of habitat and forage.

2.2.5.1 Exotic Species Introductions

The introduction of herbaceous exotics, particularly annual grasses, has fundamentally altered the fire-ecology of southern coastal California and significantly affected vegetation dynamics. Annual grasses increase the potential for fire by changing the amount, distribution, and timing of available fuels. When coupled with the increased opportunity for fire starts associated with urbanization, a feedback cycle is introduced that can lower fire return intervals beyond the capacity for native species to recover. Significant species shifts and even complete loss of native vegetation can occur. This type-conversion of shrubland to annual grassland has been widely observed in California (Keeley, 1990, Keeler-Wolf 1995, Minnich & Dezzani 1998).

Hybridization among native and non-native plants can result in the loss of native species or native variants of species. For example, the flower of the inland variety of California poppy is orange while in the coast variant the flower is yellow. When the orange variant is transplanted into areas dominated by the yellow variant, the yellow variant can be lost. This loss is probably due to genetic recessiveness of the yellow variant and not that the orange variant is more vigorous and thus out-competes the yellow variant.

2.3 Graphic Models of the Mediterranean Coast Network Parks

All of the factors discussed above were folded into a series of hierarchical block and arrow models. The process initially focused on the Santa Monica Mountains and was a terrestrial vegetation based approach that encompassed the suite of anthropogenic drivers, stressors, and effects identified above. The Santa Monica Mountains model (Figure 2.3) is divided into five primary components. Issues relative to vegetation are important in defining structure in Mediterranean-type ecosystems and, therefore, play a central role in the biotic aspects of these ecosystems worldwide. The interrelationships of the physical components of the Santa Monica Mountains including geomorphology, hydrology, climate, and air are included in the model as are the wildlife elements of concern. The effects of urbanization are extremely important, affecting in one way or another all components of the system. Exotic or alien plants are highlighted and are a significant influence on native vegetation communities and wildlife. Fire, while standing basically alone in the model, is probably the single major factor determining the structure of vegetation communities in the Santa Monica Mountains (Moreno & Oechel, 1994; *c.f.* Trabaud, 1994).

Each of the major components of the model is grouped by color: Anthropogenic drivers and stressors are gray; Water, Air and Climate are generally dark blue; Geological resources and associated process are brown; Vegetative resources and associated ecosystems process are in various shades of green; Fire is in red; Vertebrates and invertebrates are in light blue, and exotic plants are in a mixture of orange/red. Where possible these color relationships are carried throughout all the various sub-models. Where there is an interaction of model elements, blocks are a mixture of the colors indicating the grouping of the interacting factors. Elements of this model that contribute to vital sign selection are presented in greater detail in a series of sub-models (Appendices VIII & IX) developed by workshop participants, natural resource managers, and invited subject matter experts.

The Santa Monica Mountains NRA model was used as a benchmark for establishing a similar model for Cabrillo NM and the Point Loma area. The rocky intertidal was incorporated superficially in the Cabrillo model and a marine sub-model was developed to capture the significant components of the marine intertidal that should be considered in developing a list of candidate vital signs (see Figure 2.4). Using these models as a basis for discussion, several resource specific sub-models were developed for focal species, species assemblages, or communities of vital importance to Cabrillo NM and/or Santa Monica Mountains NRA.

Mediterranean-type ecosystems are disturbance driven with frequent natural events (chronic intrinsic disturbance) being responsible for normal vegetation community structure and habitat patch dynamics. Structural and organizational shifts in Mediterranean-type ecosystems integrity are more likely to be the result of events happening on an extreme temporal and/or spatial scale (acute intrinsic or extrinsic disturbance) than that of normally occurring events.

Ecosystem function generally relates to energy transfer or cycling through the physical and biotic elements of a prescribed natural entity having living and nonliving components and a defined spatial and temporal extent (King, 1993). While ecosystems have structure and hierarchical organization, some feel that the concept of ecosystem function is incomplete if the focus is solely on community and population processes (King, 1993). For this reason a generalized energy flow model centered on the biotic elements of the southern California Mediterranean-type ecosystem was prepared (Figure 2.5). The model presents the major structural components (populations and communities of the Santa Monica Mountains) organized by their functional role in energy transfer. This model was used as a template for a similar model for Cabrillo NM which is presented in Appendix X.

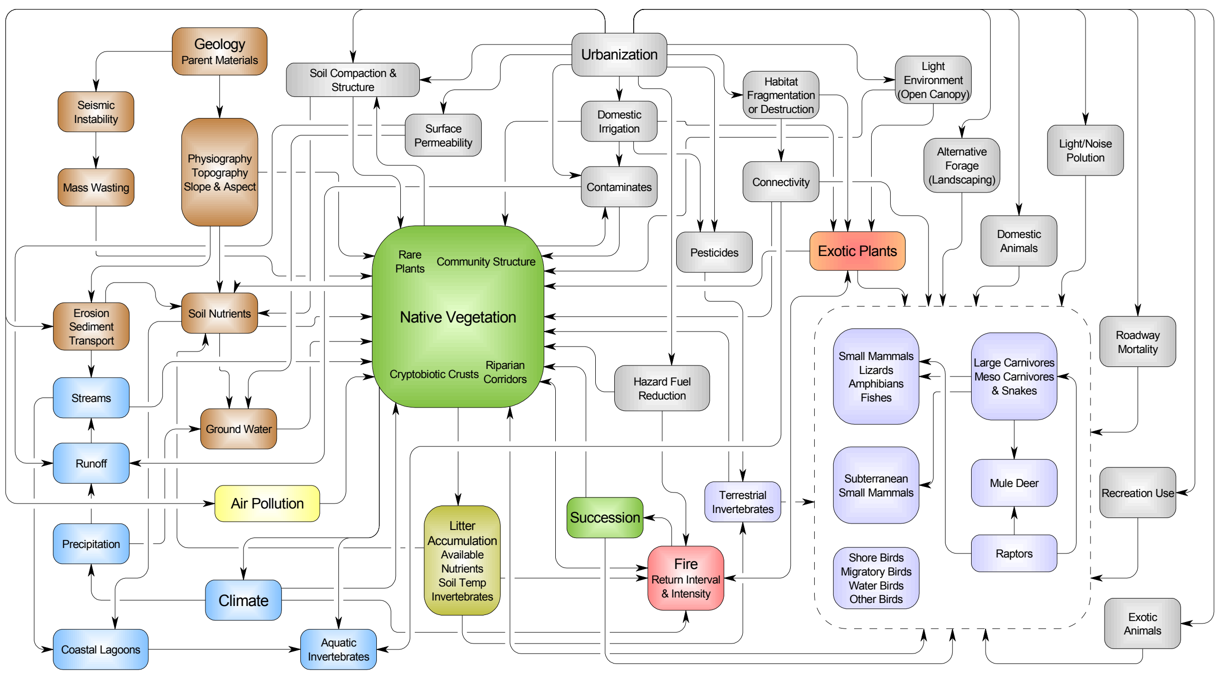

Figure 2.3 Block and Arrow representation of ecosystems components, characteristics, and processes for the Santa Monica Mountains NRA and to a lesser extent Cabrillo NM and Channel Islands NP.

While the general model and sub-models presented herein (Figures 2.3 & 2.5; Appendix VIII & IX) focus on the Santa Monica Mountains there is sufficient generality relative to processes in the southern California Mediterranean-type ecosystem to reflect conditions and relationships within Cabrillo National Monument and Channel Islands NP as well. Deviations from this generality for the Channel Islands include: 1) a lower frequency of natural fire, 2) the presence of significant numbers of endemic species and subspecies on the islands, 3) widespread impact of non-native grazing animals resulting in widespread conversion of native plant communities to non-native dominated communities, and 4) a substantially greater importance and influence of the marine environment. The ecosystem of the Channel Islands could be called a Maritime-Mediterranean Ecosystem. Because of this maritime influence summer drought is not as extreme an event on the islands. Despite these differences vegetation is very similar to the mainland, but with beach dune, coastal bluff, and sea cliff communities much more prevalent. Santa Cruz Island also hosts several groves of coniferous forest on some north-facing slopes. Air temperature is moderated by the maritime influence and winter frost is usually not a factor on the islands. Wind pruning of vegetation is more common on the islands than in the Santa Monica Mountains.

Deviations from the general model at Cabrillo National Monument include: 1) the total suppression of fire for most of the last century, 2) the occurrence of some Baja succulents that are not found in the Santa Monica Mountains, and 3) the increased significance of the coastal marine environment of Point Loma. A summary of these ecosystems processes and elements is presented in Figure 2.4 and are discussed with the models and sub-models for Cabrillo National Monument (Appendix X).

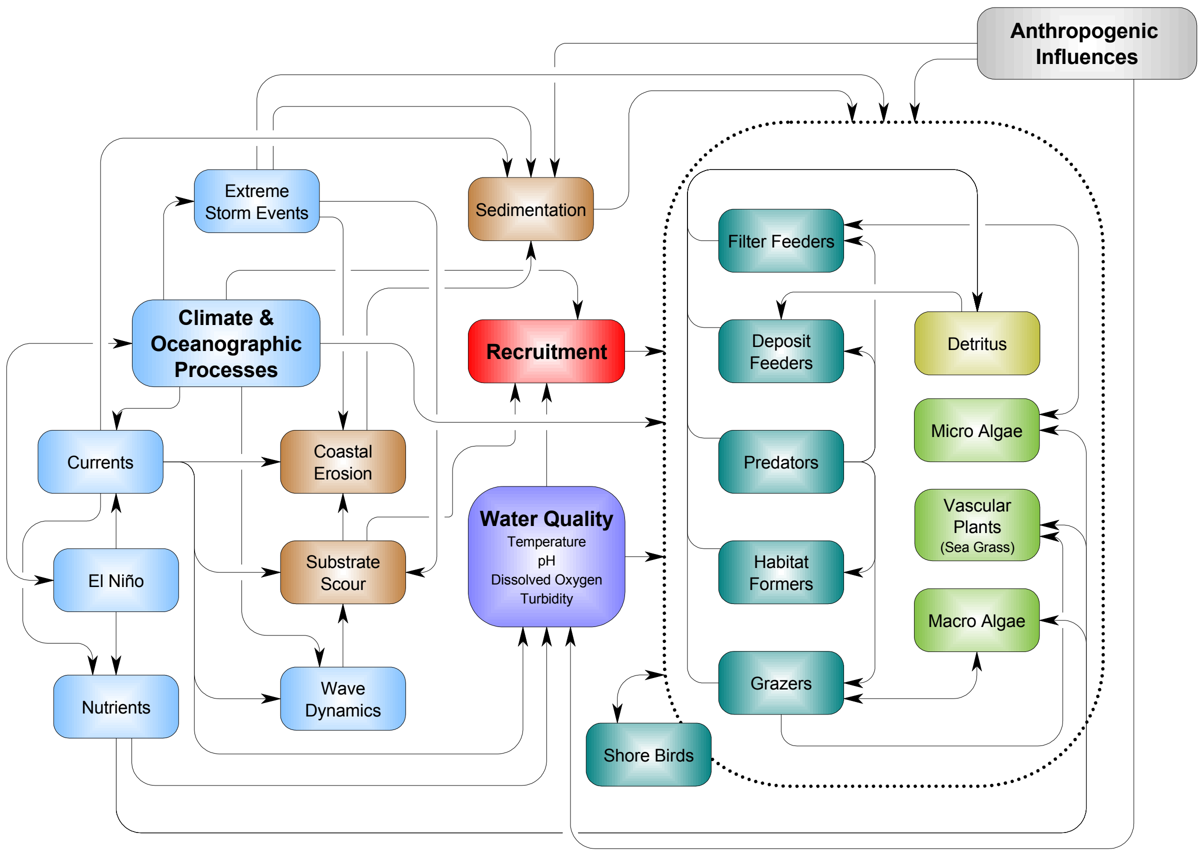

Figure 2.4 Block & Arrow diagram of the primary factors contributing to the structure and integrity of the marine intertidal of Cabrillo NM and the Point Loma penninsula.

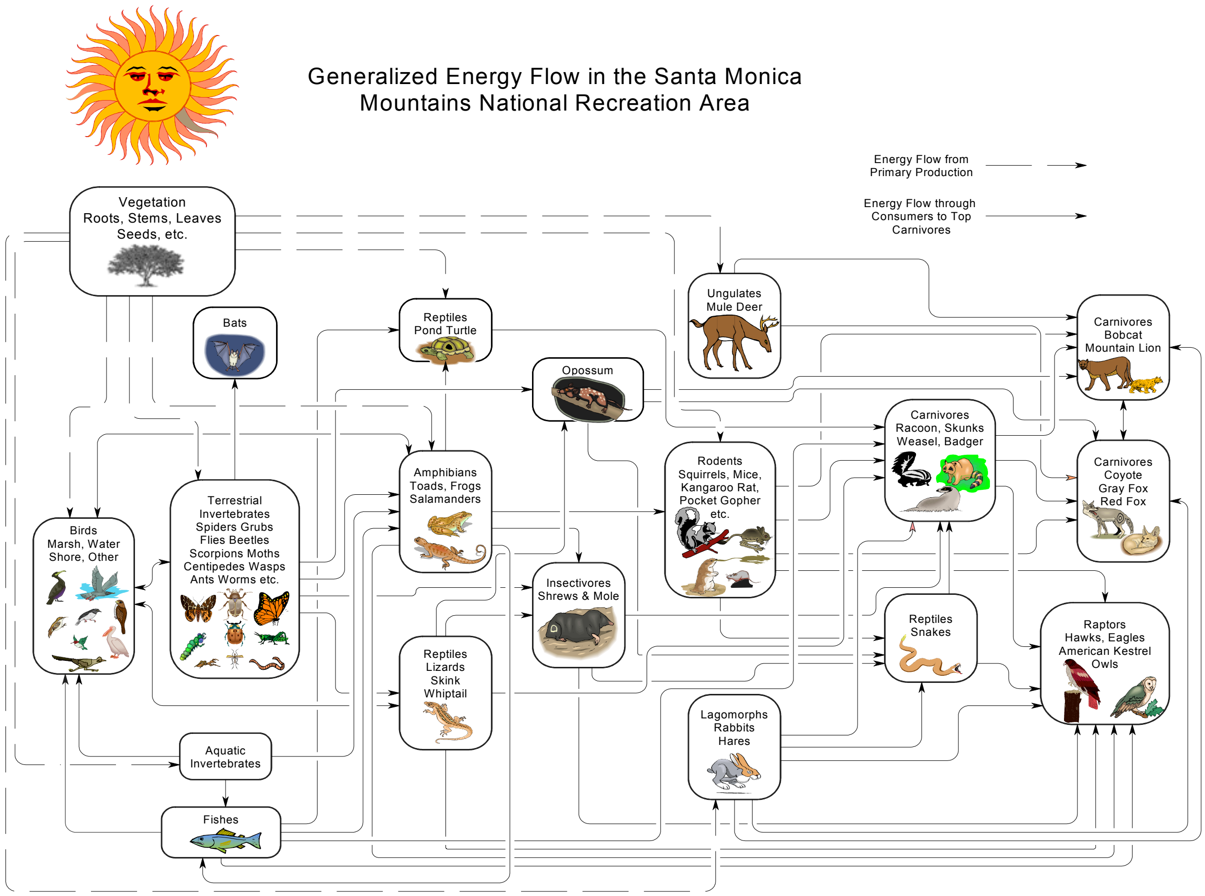

Figure 2.5 Generalized energy flow diagram in the Santa Monica Mountains

3 Vital Signs

3.1 Vital Signs Prioritization

Vital signs prioritization was conducted jointly for Cabrillo NM and Santa Monica Mountains NRA. This process involved development of a computer database for scoring of candidate vital signs by natural resource managers and subject matter experts. Each candidate vital sign was scored relative to it's ecological relevance, feasibility of implementation, and interpretation and utility. After raw scores were received, several weighting systems were applied where different levels of emphasis were applied to each of the three considerations mention above. Weighted candidate vital signs were ranked, reviewed and lumped according to predefined ecosystem attributes and features within specific categories of vital signs. Details of each step in this process are described below.

3.1.1 Prioritization Database Design

Candidate vital signs, as developed from workshops, conceptual models, and discussions with resource managers were entered into an MS Access© 2000 database. A hierarchical scheme for organizing the database was developed and is presented in table 3.1. Within the description of each candidate vital sign, we included a field on the ecosystem resource-at-risk in order to better justify the inclusion of a specific candidate vital sign. The names given to each element in the hierarchy were chosen for database functionality and not necessarily to be consistent with current ecological theory or practice. The hierarchy was also developed to help scorers understand the context for each candidate vital sign. In an effort to reduce redundancy, vital signs that were similar across network parks were consolidated. Overall, a total of 70 candidate vital signs were included in the database; 27 specifically related to Cabrillo, 12 to Santa Monica Mountains, and 31 which were applicable to both parks.

Table 3.1 Vital sign ranking database hierarchical organization. See examples of this in Tables 3.4 & 3.5.

Category	Definition
Property	Major Ecosystem element or process for grouping characteristics of candidate vital signs.
Feature	Macro-scale component of an ecosystem property that is thought or known to have significant influence on the state of ecosystem function and integrity.
Attribute	A valued ecosystem component, process, or resource that when coupled with a specific resource-at-risk suggests a metric or suite of metrics that may be evaluated to provide an indication of the status and/or trend in status of the attribute and resource-at-risk. Enumeration of the specific metrics associated with the attribute and resource-at-risk can provide insight into the overall health or integrity of an ecosystem and provide resource managers with information from which to formulate actions to eliminate or ameliorate the risk to the ecosystem component, process, or resource. The combination of attribute and resource-at-risk forms an ecosystem vital sign.
Resource-at-Risk	Ecosystem component, process, or resource that may be associated with one or more ecosystem attributes and which is at risk due to its link to ecosystem stressors.
Source of Risk	Specific process or influence of an attribute on a resource-at-risk.
Measure	Specific quantitative characteristic or metric of a resource-at-risk that when measures, analyzed, and interpreted can provide evidence for determining ecosystem health or integrity.
Justification	Characteristics of an attribute and resource-at-risk that justify their consideration as a candidate vital indicator of ecosystem health.

Each of the candidate vital signs was scored either high, medium, low, none, or no opinion based upon their ecological relevance, feasibility of implementation, and interpretation and utility (Table 3.2). A score of high was recorded as a "1", medium was recorded as "0.66", low was recorded as "0.33", and none as "0". No opinion was also scored as "0". Several different weighting schemes for each level of relevance were evaluated based on different perceptions of the importance that each level should receive in prioritizing vital signs. After a vigorous discussion park resource managers in consultation with the network technical committee weighted ecological relevance 50% of the total rank score. Feasibility of implementation and interpretation and utility were each weighted at 25% of the total score. The initial score was calculated by multiplying the average score for each rating criteria by its weighting value then summing the results across the three rating criteria. The final prioritization score for each candidate vital sign was obtained by averaging individual weighted scores across all scorers.

Table 3.2 Ranking criteria for candidate vital signs

Criteria	Definition
Ecological Relevance:	There is a strong, defensible linkage between the indicator and the ecological function, feature, or critical resource it is intended to represent. Based on your understanding of Mediterranean-type ecosystem function and conditions, this ecosystem function, feature, or resource is of high ecological importance. In your opinion, the indicator may provide early warning of undesirable changes to an important function, feature, or resource condition, and is sufficiently sensitive that small changes in the indicator can be used to detect a significant change in the target resource or function. Indicator data, at whatever scale or level of ecological organization it is collected (i.e., individual, population, community, or landscape) may be complementary to data from other indicators collected at other scales or levels of organization.
Feasibility of Implementation:	Well-documented, scientifically sound protocols exist for measuring the indicator, and implementation of the protocols is feasible given the constraints of site accessibility, sample size, equipment required, etc. Sampling and analysis techniques are cost-effective and are likely to provide data of high value. High value data have low measurement error and are obtained using sampling techniques that are repeatable and comparable when collected by different, but qualified, personnel.
Interpretation and Utility:	The proposed indicator will provide data that can clearly represent the status and trends of an ecosystem function, feature, or resource and can be understood and accepted by scientists, policy makers, and the public. Data collected will be comparable with data from other monitoring studies being conducted elsewhere in the region by other agencies, universities, or private organizations. The proposed indicator will provide information to support management decisions, to quantify the success of past management actions, or to guide adaptive management strategies in the future.

Once the database was fully functional it was migrated to an internet-based application and some 160 partners, cooperators, researchers, regulators, resource managers, and other friends of the Santa Monica Mountains National Recreation Area and Cabrillo National Monument were invited to rank the candidate vital signs. While 30 people responded to our request not all of them ranked every candidate vital sign.

Following the prioritization exercise the results were reorganized under a new hierarchy that was based upon an ecosystem structural organization suggested by the Heinz Center (Anonymous, 2002) for articulating nationwide indicators of ecosystem health (Table 3.3). Elements of the property, feature, and attribute values were reorganized into a redefined suite of ecosystem features that were consistent with NPS monitoring program definitions, and selected publications on ecosystem organization, hierarchy, and functionality (King, 1993; Reiger, 1993; Golley, 2000; Müller & Windhorst, 2000; Noon, 2003). This effort was undertaken to streamline the presentation of vital signs and to eliminate ambiguity in articulating the systems and monitoring context of a particular vital sign or suite of vital signs.

3.2 Vital Signs Selected for Monitoring

To select priority vital signs for Santa Monica Mountains National Recreation Area and Cabrillo National Monument, park resource staff evaluated the results of the internet based ranking exercise. This review allowed the application of several alternative weighting systems to the ranking scores, presented opportunities for combining monitoring efforts, and revisited each potential vital sign in the context of ecological stressors, conceptual models, and monitoring feasibility. An important goal of this review process was to maximize the total number of relevant vital signs that could be monitored by linking related concerns while ordering the candidate vital signs according the results of the prioritization exercise. This evaluation resulted in the identification of 19 ecosystems features encompassing 58 measurable attributes for Cabrillo NM and 10 ecosystems features encompassing 42 measurable attributes for Santa Monica Mountains NRA. Within each group of ecosystem features attributes were ordered based upon their rank from the web based prioritization exercise. This process was intended to provide a conceptual basis for evaluating ecosystem attributes. For instance the ecosystem feature Climate can have a significant impact on soil erosion and slope stability during extreme storm events. The combination of ecosystem feature and attribute constituted the final list of candidate vital signs for the

Mediterranean Coast Network. This process resulted in a list of vital signs stratified by ecosystem characteristic and features and prioritized by attribute rank.

As monitoring protocols are developed for the priority vital signs the juxtaposition of prioritized attributes within specific ecosystem features allows the potential for grouping of vital signs and the streamlining of monitoring protocol development to include similar or complementary agents of change. This grouping, when appropriate and feasible, can add breadth to collected data and sensitivity to data interpretation providing a more complete picture of the condition or magnitude of trend in condition of a vital ecosystem process or component. Feature/Attribute combinations with a score of 80.00 or higher were selected as the priority vital signs for monitoring planning. Detailed monitoring protocols will be developed for these vital signs. These vital signs are highlighted in pink in tables 3.4 and 3.5. Water quality and water quality related monitoring will be done in the network independent of the results of the prioritization exercise. Water quality related attributes are highlighted in light blue in table 3.4 and 3.5.

Table 3.3 Categories of ecosystem indicators (vital signs) as proposed by the Heinz Center for Science, Economics, and the Environment.

Ecosystem Characteristics	Vital Sign Description
Biological Components	
Plants & Animals	Status of native and non-native plant and animal species.
Biological Communities	Condition of the plant and animal communities that make up an ecosystem.
Ecological Productivity	Plant growth on land and in the water.
Chemical & Physical Conditions	
Nutrients, Carbon, & Oxygen	Amounts and concentrations of key plant nutrients (nitrogen & phosphorous) and key ecosystem elements (oxygen & carbon).
Chemical Contaminates	Numbers of selected contaminants found in ecosystems, and how often these chemicals exceed regulatory or advisory thresholds.
Physical Conditions	Condition of key aspects of the physical makeup of an ecosystem, such as erosion or water temperature.
Human Use	
Food, Fiber, & Water	Amounts and values of key products for human use.
Other Services, Including Recreation	Tangible and intangible services provided by ecosystems.
System Dimensions	
Extent	Area of an ecosystem or land cover type and its major components.
Fragmentation & Landscape Pattern	Shapes and sizes of patches of an ecosystem type, and their relation to one another.

3.2.1 Proposed Vital Signs for Cabrillo NM

All of the ecosystems attributes ranked in the prioritization exercise for Cabrillo NM were grouped within 19 ecosystems features. These features were nested within four basic ecosystem characteristics (Table 3.4, Anonymous, 2002). These attributes were then ranked in order of priority within one of the 19 ecosystems features. For example, when examining the biological components of the Cabrillo NM ecosystem the impacts of exotic species introductions on the native plant community of Point Loma was ranked first priority in terms exotic species introductions and first in terms of the biological components of the ecosystem and first overall as a vital signs for monitoring. Marine Vegetation of the intertidal at Cabrillo NM was ranked as the second most important biological component for monitoring and first among focal resources (see Table 3.4).

3.2.2 Proposed Vital Signs for Santa Monica Mountains NRA

All of the ecosystems attributes ranked in the prioritization exercise for Santa Monica Mountains NRA were grouped within ten ecosystems features equivalent or similar to those of Cabrillo NM, these were nested within the same four basic ecosystem characteristics (Table 3.5) as for Cabrillo NM. Attributes were then ranked in order of priority within one of the ten ecosystems features. For example, when examining the biological components of the Santa Monica Mountains NRA ecosystem the impacts of exotic species introductions on the native plant community was also ranked first priority in terms exotic species introductions and first in terms of the biological components of the ecosystem and first overall as a vital signs for monitoring. The coastal shrub community of the Santa Monica Mountains was ranked as the second most important biological component for monitoring and first among focal resources (see Table 3.5). As with Cabrillo NM Feature/Attribute combinations with a score of 80.00 or higher were selected as the priority vital signs for monitoring planning and detailed monitoring protocols will be developed for these vital signs. These vital signs are also highlighted in alternating shades of pink as with those of Cabrillo NM. Water quality related vital signs are highlighted in light blue.

Table 3.4 Candidate monitoring vital signs for Cabrillo NM stratified by ecosystem characteristic, feature, and attribute and prioritized by their rank score within the hierarchal strata of Ecosystem Characteristic and Feature.

Ecosystem Characteristics	Feature	Attribute	N	Score
Biological Component	Exotic Species Introductions	Native Vegetation	17	93.63
		Native Reptiles, Amphibians and Invertebrates	18	86.11
		Native Bird Community	16	80.21
		Marine Vegetation	13	67.31
		Intertidal Invertebrates	13	58.97
	Focal Resources	Marine Vegetation	14	91.07
		Coastal Shrub Community	18	89.35
		Chaparral Community	17	86.76
		Rare Plant Populations and Habitat	18	86.57
		Terrestrial Herpetofauna	18	86.57
		Intertidal Invertebrates	14	86.31
		Meso-carnivores	17	82.35
		Native Grassland Community	18	77.31
		Birds - Breeding Raptors	16	75.52
		Birds - Endangered, Threatened, Rare and Sensitive Species	16	73.44
		Small Mammals	17	71.08
		Birds - Resident Passerine Species	17	70.59
		Birds - Migratory	16	66.67
		Terrestrial Invertebrates	16	66.67
		Fish	12	60.42
		Bat Diversity & Abundance	17	58.82
		Cryptobiotic Crusts	19	57.46
		Marine Plankton	12	56.94
		Meso-herbivores	18	53.70
		Birds - Diving and Shorebirds	16	53.65
		Soil Microbial Biodiversity	18	44.91

Chemical & Physical Condition	Air Quality	Native Vegetation	21	71.03
		Lichen Tissue Chemistry (Ozone)	21	69.84
		Visibility	18	58.33
	Climate	Marine Vegetation	15	73.89
		Native Vegetation	20	73.33
		Soil Structure & Stability	17	53.43
	Coastal Features and Processes	Intertidal Community	13	67.95
		Sediment Transport and Erosion	17	55.39
		Shoreline Stability	17	45.10
	Geomorphology - Geomorphic Processes	Hill Slope Stability	16	43.75
		Sediment Transport	17	43.63
	Geomorphology - Soils	Soil Chemistry	16	46.88
	Ground Water Hydrology	Fresh Water Seeps	18	57.87
		Water Quality - Ground Water	18	54.17
	Marine Hydrology	Larval Transport	13	61.54
	Marine Water Quality	Intertidal Community	13	75.64
		Marine Water Chemistry	14	71.43
		Marine Nutrient Dynamics	13	63.46
	Nutrient Dynamics	Lichens and Native Vegetation	18	64.81
Human Use	Dark Night Sky	Nocturnal Animal Community	18	56.94
	Habitat Alteration and Resource Handling	Intertidal Community	14	75.60
	Natural Soundscape	Wildlife Behavior	18	53.70
	Park Management	Native Vegetation	17	75.49
	Resource Harvesting	Intertidal Community	11	62.88
	Resource Management, Monitoring & Research	Marine Biota	12	74.31
System Dimension	Fire Return Interval	Native Plant Communities Structure	18	86.11
	Landscape Pattern	Connectivity	18	81.94
		Habitat Patch Size & Dynamics	18	81.02
		Native Animal Communities	17	75.49
		Native Vegetation	19	74.56
		Native Plant Restoration Success	18	74.54
		Natural Vegetation Dynamics	19	71.93

3.2.3 Relationship of Vital Signs to Conceptual Models

Biological Component:

Exotic Species Introductions – Intertidal Flora & Fauna

The rocky intertidal communities of Cabrillo National Monument make up the dominant marine resources of the park. These intertidal communities compose one of the most protected examples of turf-dominated rocky intertidal habitats in southern California. Changes in the intertidal zone could be indicators of larger regional water quality and ecological alterations. Marine vegetation and invertebrates provide structure and food for the remainder of the community. Fish can serve as important predators and grazers of intertidal organisms and can serve to link the intertidal to near-shore subtidal environments. Marine plankton serves as a source of food as well as individuals for new generations of benthic adults. Exotic species introductions, especially marine algae, in the marine environment have the capacity to completely displace native species having significant and dramatic impacts of native system structure, integrity and function.

Exotic Species Introductions – Vegetation

Monitoring of exotic plant species was consistently ranked by survey respondents as the top priority under the five alternative weighting schemes considered for ecological relevance, feasibility of implementation, and interpretation and utility. This reflects the central role of vegetation in terrestrial Mediterranean ecosystems, the importance of exotic plant species as indicators of community perturbation and changes in ecological integrity, and the ability of many exotic plant species to dramatically change ecosystem structure and function. This highest priority ranking also indicates the opinion of local experts that there are manageable dimensions to the exotic plant problem and that with effective monitoring, control of exotics and mitigation of their impacts are possible.

Table 3.5 Candidate monitoring vital signs for Santa Monica Mountains NRA stratified by ecosystem characteristic, feature, and attribute and prioritized by their rank score.

Ecosystem Characteristics	Feature	Attribute	N	Score
Biological Component	Exotic Species Introductions	Native Vegetation	17	93.63
		Native Reptiles, Amphibians and Invertebrates	18	86.11
		Native Animal Community	17	84.31
		Native Bird Community	16	80.21
	Focal Resources	Coastal Shrub Community	18	89.35
		Chaparral Community	17	86.76
		Rare Plant Populations and Habitat	18	86.57
		Terrestrial Herpetofauna	18	86.57
		Meso-carnivores	17	82.35
		Aquatic Herpetofauna	16	82.29
		Riparian Plant Communities	17	81.86
		Aquatic Invertebrates	15	81.11
		Oak Woodland Community	17	80.88
		Wetland Community	16	80.73
		Native Grassland Community	18	77.31
		Birds - Breeding Raptors	16	75.52
		Birds - Endangered, Threatened, Rare and Sensitive Species	16	73.44
		Mountain Lions	18	72.69
		Small Mammals	17	71.08
		Birds - Resident Passerine Species	17	70.59
		Birds - Migratory	16	66.67
		Terrestrial Invertebrates	16	66.67
		Fish - Steelhead	18	59.72
		Bat Diversity & Abundance	17	58.82
		Cryptobiotic Crusts	19	57.46
		Soil Microbial Biodiversity	18	44.91

Chemical & Physical Condition	Climate	Native Vegetation	20	73.33
		Soil Structure & Stability	17	53.43
	Freshwater Quality	Water Chemistry	17	74.51
		Freshwater Nutrient Dynamics	17	69.61
	Geomorphology - Geomorphic Processes	Hill Slope Stability	16	43.75
		Sediment Transport	17	43.63
	Geomorphology - Soils	Soil Chemistry	16	46.88
	Ground Water Hydrology	Fresh Water Seeps	18	57.87
		Water Quality - Ground Water	18	54.17
	Stream Hydrology	Stream Flow	19	73.25
		Riparian Aquatic Communities	18	69.91
System Dimension	Fire Return Interval	Native Vegetation	18	86.11
	Landscape Pattern		18	81.94
		Habitat Patch Size & Dynamics	18	81.02
		Native Animal Communities	17	75.49
		Native Vegetation	19	74.56

Monitoring Approach: The network will develop a comprehensive vegetation monitoring program that will focus on the distribution and status of invasive exotic plants. Changes in native community composition and structure would be monitored as part of this program. Given the limited resources available for monitoring, emphasis will be placed on monitoring ecologically disruptive exotics that are demonstrated as invasive elsewhere, but are not yet common in the Santa Monica Mountains. Similarly, monitoring will focus on areas where conditions believed to promote exotic establishment are most pronounced, with less emphasis placed on areas believed to have greater ecological integrity. Priority will be given to the plant community types as generally recommended by respondents with the exception of chaparral. Chaparral is relatively less threatened and more resistant to establishment of exotics than other plant community types at Santa Monica Mountains and thus, it will receive relatively less emphasis than recommended by respondents for the Mediterranean network in general. Riparian communities, critical to ecosystem function at Santa Monica Mountains, will receive relatively greater emphasis.

Focal Resources – Vegetation

Respondents also ranked plant vegetation community types as high priority vital signs (within the top 20%) under all alternative weighting schemes. This again reflects the recognition of the defining importance of vegetation communities to Mediterranean ecosystems. The two most common coastal Mediterranean-type ecosystem vegetation community types in California, chaparral and coastal sage scrub, received the highest vegetation community rankings. Greater priority was given to coastal sage scrub as the plant community under greatest threat. Riparian communities, oak woodlands, freshwater wetlands, and native grasslands were ranked as lower priorities. These communities are important in the Santa Monica Mountains but not at Cabrillo and we presume that these rankings to some extent reflect the efforts of respondents to identify priorities common to both parks.

Native vegetation provides the main structure, both as habitat and as the primary source of energy, for all Mediterranean-type ecosystems. The status, distribution, and composition of species, populations, and community types directly reflect the health of these habitats and of the ecosystem as a whole. Information on the presence and distribution of rare, unusual, and endemic species, and of rare and unusual plant communities can lead to a better understanding of many other biotic and abiotic resources.

Focal Resources – Rare Plant Species and Habitats

Respondents ranked rare plant populations and habitats within the top five monitoring priorities across all alternative weighting schemes. This ranking appears to reflect the respondents' concern for these unique species, but not necessarily the utility of these rare plants as vital signs. Most rare and sensitive plant species at Santa Monica Mountains, particularly state and federally listed species, occur in relatively unique and limited habitats (many are endemic) and therefore are not useful wide-scale indicators of overall system change. Given limited monitoring resources we will at this time place low priority on rare plant monitoring under the vital signs monitoring program. We will, however, continue to inventory these species and seek funding elsewhere for studies of their demography and ecology. If research demonstrates that they are more important wide-scale indicators of ecosystem integrity than we currently believe, we can incorporate them into the vital signs monitoring program.

Focal Resources – Terrestrial Fauna

Reptiles may be particularly sensitive indicators of ecosystem change due to their position in food webs as both predators and prey. The interconnections within the reptile community (including larger snakes and lizards eating smaller lizards and snakes) and their role as prey for predatory birds make them sensitive to changes in several animal communities. At the opposite end of the food web, reptiles and amphibians rely heavily on smaller organisms for food, thus they are potential indicators of problems in trophic levels below them.

Mammals as larger and more mobile organisms may be impacted by stressors that do not affect smaller terrestrial organisms that rely on smaller habitat patches or travel shorter distances. In addition, mammals may also be impacted by their food resources at trophic levels below them. Mammals are also found in several niches in the ecosystem from herbivores (small and medium-sized) up to large carnivores with extensive home ranges, again increasing the potential that they may be affected by factors operating at multiple scales.

Vital signs in this category generally focus on species groups sensitive to the effects of habitat fragmentation, urban encroachment, and habitat alteration. Top priority vital signs address three levels of concern: species diversity within habitat fragments, animal movements within and between fragmented areas, and potential landscape-level distribution changes that occur in fragmented landscapes.

Terrestrial reptiles and amphibians were selected for monitoring species diversity in order to detect changes in response to habitat loss, fragmentation, and alteration. Terrestrial reptiles and amphibians were the highest priority for a number of reasons. Most importantly, they have a high potential diversity with up to 35 species occurring in the mountains and a number of these species are already of concern in southern California (e.g., coastal horned lizard, legless lizard, whiptail lizard). The techniques used to monitor this group are also well-established and widely used throughout the region and we already have excellent baseline data for a number of areas within network parks, enabling us to coordinate with other agencies to look for broad scale and long-term trends. The monitoring techniques for this group are also reasonably easy to learn and use, such that interns and technicians can quickly assist with data collection.

Reptiles also make up an important part of the terrestrial system from the perspective of our conceptual model. Snakes and lizards together represent by far the most species of any of the faunal components of our model and they are important both trophically, and in terms of urban impacts. Small mammals are the next most diverse group in the model and they represent at most half as many species. Snakes are also predators of small mammals and birds, while both lizards and snakes are part of the prey base of a number of other animal groups including raptors, mammalian carnivores, and other snakes. Finally, both lizards and snakes are potentially impacted by habitat fragmentation and alteration, with snakes also being sensitive to other human activities such as vehicle traffic, direct poaching, killing, and fire.

Other than reducing diversity, another significant impact of habitat fragmentation and urbanization on wildlife communities is reduction in the abundance and distribution of species such as mammalian carnivores and raptors that require large areas of intact habitat. We selected medium-sized carnivores for monitoring because they can be important indicators of landscape and ecosystem integrity in the face of fragmentation. While meso-carnivores are difficult to monitor, they are more reasonable targets for study than extremely low density large carnivores such as mountain lions or the rare and more habitat-specific carnivores such as badgers or ringtails. As reflected in the terrestrial vertebrate submodel of our conceptual model, these carnivores have many trophic connections as predators, and are affected by many aspects of urbanization. Carnivores are undoubtedly affected by the loss and isolation of habitat, they may experience increased mortality from secondary poisoning, and they are often impacted by mortality from vehicles. These carnivores may also be affected in positive ways by some urban influences, including anthropogenic food sources for omnivorous coyotes and foxes and increased prey populations of herbivores in irrigated urban areas adjacent to parkland.

Chemical & Physical Condition:

Water Quality – Water Chemistry

Water quality and quantity affect both marine and fresh water components of network ecosystems. Poor water quality in marine environments can lead to lethal and sub-lethal effects on intertidal organisms. Freshwater seeps and their associated ground water sources can provide necessary sources of water during the dry periods; poor water quality or lack of water in these seeps can significantly affect the presence of both terrestrial and aquatic species.

Water Quality – Nutrient Dynamics

Nutrient cycling in ecosystems affects the presence and distribution of species, populations, and communities in both marine and terrestrial environments. Small-scale nutrient loadings can lead to eutrophication and exponential phytoplankton or seaweed growth in the marine system. Upwelling periods result in increased growth of opportunistic algal species. Inter-annual climatic phenomena such as El Niño and La Niña can cause significant nutrient depletion or enrichment. All of these alterations in nutrient levels have the potential to cause large changes in marine flora with cascading effects on higher trophic levels.

Water Quality – Stream Hydrology

Survey respondents did not rank this potential vital sign highly (although within the top 50%). However, Santa Monica Mountains' staff and several respondents believe that changes in stream hydrology are a potentially important influence on exotic species establishment and vegetation change in the park. A small number of studies and much observational evidence indicates that both the amount and seasonal availability of water have increased with increasing urbanization in and adjacent to the Santa Monica Mountains causing historically intermittent streams to flow throughout the year. This has visibly changed the composition and structure of streamside vegetation in many areas and is believed to be facilitating ingression and establishment of exotic plant species that have relatively high water requirements. In addition, these increases in water availability may be increasing movement and establishment of exotic aquatic animals. We are currently seeking funding to evaluate the influence of urban runoff on the timing and amount of stream flow in the Santa Monica Mountains. Based on the findings of this study, and if resources permit, we will seek to develop a stream flow monitoring program to be linked to our vegetation monitoring program.

Water Quality – Aquatic Features and Processes

Water is a limiting resource in southern California and a significant driver in the Park conceptual models. The presence of water determines the presence and abundance of much of the Santa Monica Mountains' flora and fauna. However, urban development has a strong influence on aquatic systems by transforming ephemeral watersheds into perennial ones. In addition, increases in impermeable surfaces (i.e., paved surfaces in urban areas) result in pulses of water following storm events. These two factors result in increased erosion, stream sedimentation, and pollution from urban run-off. These physical changes can have biological consequences as well, such as loss of riparian habitat, and the spread of exotic species.

Restoration efforts in the Santa Monica Mountains, such as the re-introduction of endangered steelhead trout, depend on baseline information on our watersheds. The use of other vital signs such as benthic macro-invertebrates and aquatic amphibians also depend on information about water quality and other abiotic aquatic conditions to make predictions and correlations about possible declines. Finally, the methodologies used in monitoring water quality are well established by the Environmental Protection Agency and the U.S.G.S. and are widely used by park cooperators and California's Regional Water Quality Monitoring Programs.

Distribution and abundance of aquatic herpetofauna (specifically amphibians), including related measurements of habitat characteristics and basic water quality will be monitored. Aquatic herpetofauna, were selected for two reasons: First, they represent a group of significant and potentially sensitive animals. Many amphibian species are declining in various parts of the world, even in remote protected areas, and a number of local amphibian species are also considered sensitive. This rarity and potential for rapid decline makes this group an important resource to monitor in and of itself. Second, amphibian monitoring will provide us with important information about the status of streams in the mountains, the predominant aquatic resource in the park. Urbanization can have serious impacts on streams and monitoring native aquatic amphibians and introduced aquatic species can be a good measure of these impacts. Stream habitat in urban areas is often significantly altered by channelization, decreased riparian vegetation and increased water flows. Toxins or increased nutrients can also impair water quality in streams. In Mediterranean climates stream permanence may be greatly modified by urban runoff that occurs throughout the year, not just during the winter wet season. These impacts on stream habitats and the quality and quantity of water can then have significant impacts on both native and introduced aquatic fauna. These relationships are reflected in our overall conceptual model through the links between urbanization, domestic irrigation and increased runoff, and potential decreases in stream quality through the addition of contaminates from runoff.

While there are other aquatic faunal components that would provide useful information, specifically benthic macro-invertebrates, such monitoring is very expensive and time-consuming. In addition, invertebrates, while sensitive indicators in many ways, can also fluctuate greatly relative to seasons and habitat greatly increasing the difficulty of detecting meaningful change. We would hope to include some aquatic invertebrate sampling in our monitoring, but aquatic amphibians provide a more feasible alternative that provides valuable information about streams in the park and about the amphibian fauna itself.

System Dimension:

Fire Return Interval – Native Plant Community Structure

Fire plays a critical role in plant community dynamics and the maintenance of native diversity in Mediterranean ecosystems. Decreasing fire return intervals at Santa Monica Mountains resulting from human ignitions appear to be changing native community composition and in extreme cases have been demonstrated to cause vegetation type conversion to communities dominated by exotic species. Conversely, fire suppression at Cabrillo may be causing the loss of species requiring short fire return intervals and may be leading to chaparral community senescence. For these reasons, respondents gave high ranking to fire return interval as an indicator of potential ecosystem change. At Santa Monica Mountains, fire perimeters have been mapped by Los Angeles and Ventura County fire and public works agencies since 1925. This information is available to Santa Monica Mountains NRA which has been and will continue to be monitored and analyzed to evaluate fire return interval. Because fire return intervals, exotic species establishment, and native vegetation change are related though a series of feedback mechanisms, we will explicitly link our exotic plant species and vegetation monitoring program to the monitoring and analysis of fire return intervals. This will not only help us to more effectively examine the causal mechanisms behind exotic establishment and native vegetation change, but will allow us to extrapolate observed changes at intensely sampled small spatial scale sites to all areas of Santa Monica Mountains based on an understanding of the relationship between vegetation and fire return intervals.

Landscape Pattern – Connectivity & Habitat Patch Dynamics

Landscape characteristics, such as land use, land cover, and patterns of habitat fragmentation, habitat connectivity, patch size and patch distribution can all be critical determinants of ecosystem function. Changes in these characteristics resulting from urbanization are among the most important anthropogenic stressors—particularly in our human-dominated region. The conceptual model for the Santa Monica Mountains ecosystem illustrates the direct connections between habitat loss and fragmentation and resulting changes in wildlife communities and populations. Aside from these direct connections, landscape pattern and land use may also have major implications for fire frequency, exotic species distributions, water quality, air quality, and soil erosion.

Measurement of changes in land cover and landscape pattern will provide critical correlative information for other monitoring programs, allowing us to examine changes in other indicators relative to changes in landscape pattern. Additionally, these measures can be obtained relatively easily through remote sensing and automated procedures. Not only will this provide a great deal of information efficiently, but it may also enable us to extrapolate results of local monitoring efforts to other areas facing similar issues.

3.3 Vital Sign Measurable Objectives, Thresholds, & Management Response

Once vital signs were identified resource managers from Cabrillo and Santa Monica Mountains working in conjunction with the network technical committee attempted to identify measurable objectives, threshold values, and proposed management responses for each of the vital signs associated with each park. The results of this exercise are presented in tables 3.6 and 3.7 below. In many cases identification of specific information related to these factors will not be known until the completion of sampling and analysis protocols.

Table 3.6 Prioritized list of vital signs of ecosystem health including measurable objectives, threshold values, and proposed management response to exceeding threshold values for Cabrillo National Monument.

	Vital Sign (Feature & Attribute)	Measurable Objectives	Threshold Value	Management Response
Biological Component	Exotic Species Introductions			
	1. Native Vegetation 2. Native Reptiles, Amphibians & Invertebrates 3. Native Bird Communities	• Map plant communities and distribution of species. • Map and track changes in population sizes. • Measure the long-term changes that are taking place in the usual vegetation units or representative plant communities (e.g., *Rhus integrifolia* dominated, *Ceanothus verrucosus* dominated, coastal sage scrub, disturbed) using the following comparisons: Relative frequency of natives versus exotics, Perennials versus annuals, Comparison of frequency of graminoids, herbs, sub-shrubs, shrubs, and trees. • Determine rates of loss of terrestrial biodiversity and develop correlative models for management and long-term maintenance of declining southern coastal California habitats (e.g., Diegan coastal sage scrub, southern maritime chaparral, maritime succulent scrub, and southern coastal bluff scrub). • 27 (10%) of 267 hectares of the Point Loma Ecological Reserve's targeted lands impacted by exotic vegetation as of Fiscal Year 1999	To be Identified in protocols.	Investigate cause of change and develop appropriate management responses.

	Vital Sign (Feature & Attribute)	Measurable Objectives	Threshold Value	Management Response
		are contained through the removal of *Acacia*, *Carpobrotus*, *Eucalyptus*, *Nicotiana* and other non-native plants. • 3 (50%) of 6 hectares of Cabrillo NM's land impacted by exotic vegetation targeted by September 30, 1999 are contained through the removal of *Acacia*, *Carpobrotus*, *Eucalyptus*, *Centaurea*, *Salsola*, and other non-native plants. • 100% of Cabrillo NM's lands impacted by exotic vegetation are restored to native habitat. This includes on-going monitoring to remove any new infestations or starts of newly invasive species. • Document what herpetological species are currently found at Point Loma Ecological Reserve and compare with the 19 species that have been historically found in this area. • Detect if any of the targeted herpetological species are showing declines at present. • Determine the number of herpetological arrays, sampling periods, and sampling days per sampling period that would be needed to detect a; 30% drop in species richness, 30% drop in the relative abundance of orange-throated whiptail (*Cnemidophorus hyperythrus*) and striped racer (*Masticophis lateralis*), and some measure of drop in abundance or occupancy of western ring-necked snake (*Diadophis punctatus*) and southern Pacific rattlesnake (*Crotalus viridis*). • Determine to species 100% of the organisms in the current terrestrial invertebrate collection (based on ground-dwelling specimens collected in association with the herpetological monitoring efforts). • Develop a terrestrial invertebrate species list that includes species from numerous habitat niches (e.g., flying, shrub-dwelling, ground-dwelling).		
	Focal Resources			
	2. Coastal Shrub Community 3. Chaparral Community 4. Rare Plant Populations & Habitat 5. Terrestrial Herpetofauna 6. Intertidal Invertebrates 7. Meso-carnivores	• Detect long-term population changes in selected species including determination of normal limits of variation and potential movement beyond these limits. Use supporting data to assess or prevent impacts to the system. • Changes in cover of dominant taxa. • Changes in size frequencies of selected populations. • Patterns of diversity.	To be Identified in protocols.	Investigate cause of change and develop appropriate management responses.

	Vital Sign (Feature & Attribute)	Measurable Objectives	Threshold Value	Management Response
		systems in a larger regional context. Data will be comparable and compatible with existing data and similar programs in southern California (e.g., CHIS and MARINE). • Track long-term population changes in threatened, endangered, sensitive, and rare state- and federal-listed species of terrestrial and marine flora and fauna that are present on Cabrillo NM. • Map plant communities and distribution of species. • Map and track changes in population sizes. • Measure the long-term changes that are taking place in the usual vegetation units or representative plant communities (e.g., *Rhus integrifolia* dominated, *Ceanothus verrucosus* dominated, coastal sage scrub, disturbed) using the following comparisons: Relative frequency of natives versus exotics, Perennials versus annuals, Comparison of frequency of graminoids, herbs, sub-shrubs, shrubs, and trees.		
Chemical & Physical Condition				
	1. Fresh Water Seeps 2. Water Quality	• Inorganic and organic pollutants. • Water temperature, oxygen, turbidity, salinity, pH. • Influence of fresh water seeps and their associated ground water sources on the surrounding flora and fauna.	To be Identified in protocols.	Investigate cause of change and develop appropriate management responses.
	Marine Water Quality			
	1. Intertidal Community 2. Marine Water Chemistry 3. Marine Nutrient Dynamics	• Effects of water quality on marine organisms. • Inorganic and organic pollutants. • Body burdens in selected marine invertebrates. • Water temperature, oxygen, turbidity, salinity, pH.	To be Identified in protocols. .	Investigate cause of change and develop appropriate management responses.

	Vital Sign (Feature & Attribute)	Measurable Objectives	Threshold Value	Management Response
System Dimension	**Fire Return Interval**			
	1. Native Plant Community Structure	• Fire return interval. • Terrestrial plant community composition and biodiversity, seed bank composition and longevity.	To be Identified in protocols.	Investigate cause of change and develop appropriate management responses.
	Landscape Pattern			
	1. Connectivity 2. Habitat Patch Size & Dynamics	• Landscape-scale habitat mapping, tracking of habitat patches and connectivity using GIS and aerial surveys.	To be Identified in protocols.	Investigate cause of change and develop appropriate management responses.

Table 3.7 Prioritized list of vital signs of ecosystem health including measurable objectives, threshold values, and proposed management response to exceeding threshold values for Santa Monica Mountains National Recreation Area.

	Vital Sign (Feature & Attribute)	Measurable Objectives	Threshold Value	Management Response
Biological Component	**Exotic Species Introductions**			
	1. Native Vegetation 2. Native Reptiles, Amphibians & Invertebrates 3. Native Animal Community 4. Native Bird Communities	• Contain or reduce below current levels all ecologically damaging invasive plant species (except annual grasses). • Identify and control all new introductions of invasive ecologically damaging plant species. • Detect changes in range and number of populations of all invasive exotic, ecologically damaging species occurring at SAMO. • Detect introductions of new invasive exotic species into SAMO.	1. Detection of a 15% increase in areal extent and/or detection of 85% of newly established stands of invasive exotic species already present in the park. 2. Detection of 85% of all populations of newly introduced invasive exotic species within one year of recorded introduction.	1. Initiate eradication actions for small stands and new introductions. 2. Initiate control and habitat restoration actions for large stands.
	Focal Resources			
	1. Coastal Shrub Community 2. Chaparral Community 3. Riparian Plant Communities 4. Oak Woodland Communities 5. Wetland Community	• Determine the natural range of variability in plant community structure and composition within SAMO. • Maintain 90% of intact native vegetation in the park within historical range of species composition and structural variability • 3. Develop an integrated monitoring structure that permits analysis and increased understanding of direct and indirect anthropogenic stresses on native communities (e.g., changing fire regimes, exotic introductions, influence of trails and roads, recreational activities).	1. Detection of a 15% increase in areal extent and/or detection of newly establishing stands of invasive exotic species. 2. Detection of a 30% change in relative cover of native woody species within monitored stands.	1. Initiate exotic species control and habitat restoration actions. 2. Analyze native species change to determine cause and relation to natural temporal variation. Take appropriate mitigation action if stand is found to be outside range of natural variation and/or to result from anthropogenic factors.

	Vital Sign (Feature & Attribute)	Measurable Objectives	Threshold Value	Management Response
	6. Rare Plant Populations & Habitat	• Maintain and ultimately increase by 15% the number of individuals of each federally listed threatened and endangered species • Increase the number of stands of each species by 30%. • Detect change in population size and number of stands of threatened and endangered species. 4. Increase understanding of demography and environmental relations of threatened and endangered species.	1. Detection of a 15% decrease in population size (below the natural variability anticipated for annuals). 2. Loss of a stand of any sensitive species.	Initiate propagation, habitat restoration, and establishment of experimental populations.
	7. Terrestrial Herpetofauna	• To maintain reptile diversity at current levels throughout the park	Any long-term loss of species presence or significant decline in abundance	Work to increase the amount of relevant habitat, to decrease habitat loss and to increase connectivity
	8. Meso-carnivores	• Maintain carnivore distribution in both fragmented and unfragmented park areas, specifically for bobcats and coyotes. Monitor for presence of gray foxes in fragmented areas.	Any long-term reduction in the distribution of carnivores.	Work with partners to reduce habitat loss and to increase connectivity between remaining habitat patches, including restoring or installing usable connections across barriers. Initiate research on carnivore movement patterns, survival rates and sources of mortality.
	8. Aquatic Herpetofauna	• To maintain current distribution of successfully reproducing native amphibian species and prevent further expansion of non-native predators	Any long-term reduction in the distribution of sensitive native species such as newts, Ca. tree frogs or Western toads, or wider distribution of introduced species, particularly crayfish	Work with partners to remove introduced species from streams where possible, especially less urban streams. Consider translocating native amphibians to streams where they have been lost.
		• Assess the current conditions (biological) of each watershed and monitor for changes.	Changes in invertebrate diversity or a decline or loss of indicator species.	Identify chemical or physical factors that may contribute to their decline and work with partner agencies and organizations to reduce, restore or eliminate these impacts.

Chemical & Physical Condition	**Freshwater Quality**			
	1. Water Chemistry 2. Ground Water Quality	• Assess current conditions (physical and chemical) of each watershed and monitor for changes.	Regulatory limits and thresholds for core water quality variables. Changes in stream condition such as losses in riparian cover, increased water flow, stream bank erosion and sedimentation.	Identify factors that contribute to the decrease in water quality and work with partner agencies to reduce, restore or eliminate these impacts.
	Ground Water Hydrology			
	Water Quality	• Assess current conditions (physical and chemical) of each watershed and monitor for changes.	Regulatory limits and thresholds for core water quality variables.	Identify factors that contribute to the decrease in water quality and work with partner agencies to reduce, restore or eliminate these impacts.
	Stream Hydrology			
	Stream Flow	• Monitor amount and seasonality of stream flow in key streams within SAMO. • 2. Monitor the proportion of stream flow contributed by urban runoff.	1. Detection of a 30% increase in the average number of days that an intermittent stream flows. 2. Detection of greater than 30% urban runoff in stream flow.	Develop education programs and water management actions to promote reduction of urban runoff into streams.
System Dimension	**Fire Return Interval**			
	Native Plant Community Structure	• Record all fire perimeters and analyze fire return intervals for defined ecological units within SAMO. • 2. Increase understanding of influence of short fire return intervals on vegetation change.	Decrease in fire return interval to less than 20 years in any ecological unit.	1. Initiate sampling program to analyze potential impacts. 2. Initiate exotic species control and restoration actions to mitigate impacts. 3. Initiate a program for fire-start reduction.
	Landscape Pattern			
	1. Connectivity 2. Habitat Patch Size & Dynamics	• Track changes in land use, habitat fragmentation, habitat connectivity, patch size at a landscape level.	Changes in landscape such that diversity, distribution, or abundance of wildlife and plant populations is threatened. Changes in landscape pattern that foster increased invasion of exotic species, decreases in fire return interval, increased soil erosion and sedimentation, and other human-related impacts.	Potential management responses might include habitat restoration or other direct management of affected ecosystem components, working with planners and regulatory agencies to prevent or reduce future impacts, dissemination of monitoring results and analysis to assist other parks or agencies which may be facing similar problems in future.

3.4 Summary of Selected Vital Signs

A total of 26 unique vital signs grouped within eight ecosystems features and three ecosystems characteristics have been identified for Cabrillo NM and Santa Monica Mountains NRA (Table 3.8). These parks represent the two parks of the Mediterranean Coast Network for which primary vital signs monitoring planning is being conducted. Potential water quality vital signs have been identified for Channel Islands National Park (CHIS) and are included in table 3.8. The water quality effort of the vital signs program will include Channel Islands NP since the prototype monitoring program at Channel Islands has not adequately addressed water quality issues for that park.

Monitoring protocols for the listed vital signs will be developed beginning with the highest priority vital signs as identified in tables 3.4and 3.5, and with those monitoring programs already initiated within network parks (see table 1.7) that are identified as priority vital signs and where inventory and monitoring resources have already supported baseline resource condition data gathering.

Table 3.8 Summary of vital signs selected for Cabrillo NM, Santa Monica Mountains NRA. Vital signs are not listed in any specific priority.[18] Water quality monitoring *per se* is not part of the prototype monitoring program at CHIS and are therefore listed herein. Other ecosystem components and resources being monitored at Channel Islands NP under the prototype monitoring program are not included in this table, but are listed in figure 1.10.

Ecosystem Characteristics	Feature	Attribute	CABR	SAMO	CHIS
Biological Component	Exotic Species Introductions	Native Vegetation	✓	✓	
		Native Reptiles, Amphibians and Invertebrates	✓	✓	
		Native Bird Community	✓	✓	
	Focal Resources	Marine Vegetation	✓		
		Coastal Shrub Community	✓	✓	
		Chaparral Community	✓	✓	
		Rare Plant Populations and Habitat	✓	✓	
		Terrestrial Herpetofauna	✓	✓	
		Intertidal Invertebrates	✓		
		Meso-carnivores	✓	✓	
		Aquatic Herpetofauna		✓	
		Riparian Plant Communities		✓	
		Aquatic Invertebrates		✓	
		Oak Woodland Community		✓	
		Wetland Community		✓	
Chemical & Physical Condition	Freshwater Quality	Water Chemistry		✓	✓
		Freshwater Nutrient Dynamics		✓	✓
	Ground Water Hydrology	Fresh Water Seeps	✓	✓	✓
		Water Quality - Ground Water	✓	✓	✓
	Marine Water Quality	Intertidal Community	✓		✓
		Marine Water Chemistry	✓		✓
		Marine Nutrient Dynamics	✓		✓
	Stream Hydrology	Stream Flow		✓	
System Dimension	Fire Return Interval	Native Plant Communities Structure	✓	✓	
	Landscape Pattern	Connectivity	✓	✓	
		Habitat Patch Size & Dynamics	✓	✓	

[18] See Tables 3.4 and 3.5 for a detailed presentation of vital signs and their relative ranking one against another.

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